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ABSTRACT

The Space Exposed Experiment Developed for Students (SEEDS) Project offered science classes at the 5-12 and college levels the opportunity to conduct experiments involving tomato seeds that had been space-exposed over long periods of time. SEEDS kits were complete packages obtained from the National Aeronautics and Space Administration (NASA) for starting the experiment and reporting results. This document describes the project and reports data collected by participating classes. The document is divided into six sections. The first section describes the origins of the organization and background of the project. The next four sections discuss results of the project pertaining to: germination and growth observations patterns of the plants; the hardiness of the plants; media attention given to the possibility of radiation-induced mutations in the space-exposed tomatoes; and the excitement caused by participating in the project. The final section presents data collected from the almost 8,000 SEEDS Project Reports returned to NASA by participating investigators. Data reported includes means, standard deviations, and minimum and maximum values of various aspects of plant growth. (MDH)

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SEEDS

A Celebration of Science

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SEEDS: A Celebration of Science

NASA
National Aeronautics and
Space Administration

Elementary and Secondary Programs Branch
Educational Affairs Division
Office of External Relations
NASA Headquarters
August 1991
EP-281

IN MEMORIAM

James Gregory Marlins

Everyone associated with the NASA SEEDS Project was saddened by the death of its Director, Dr. James Gregory Marlins, on November 12, 1990. Dr. Marlins was a NASA Aerospace Education Specialist at Oklahoma State University assigned to NASA Headquarters, Washington, D.C. He conducted aerospace education seminars at colleges and universities throughout the United States and in Egypt and Jordan.

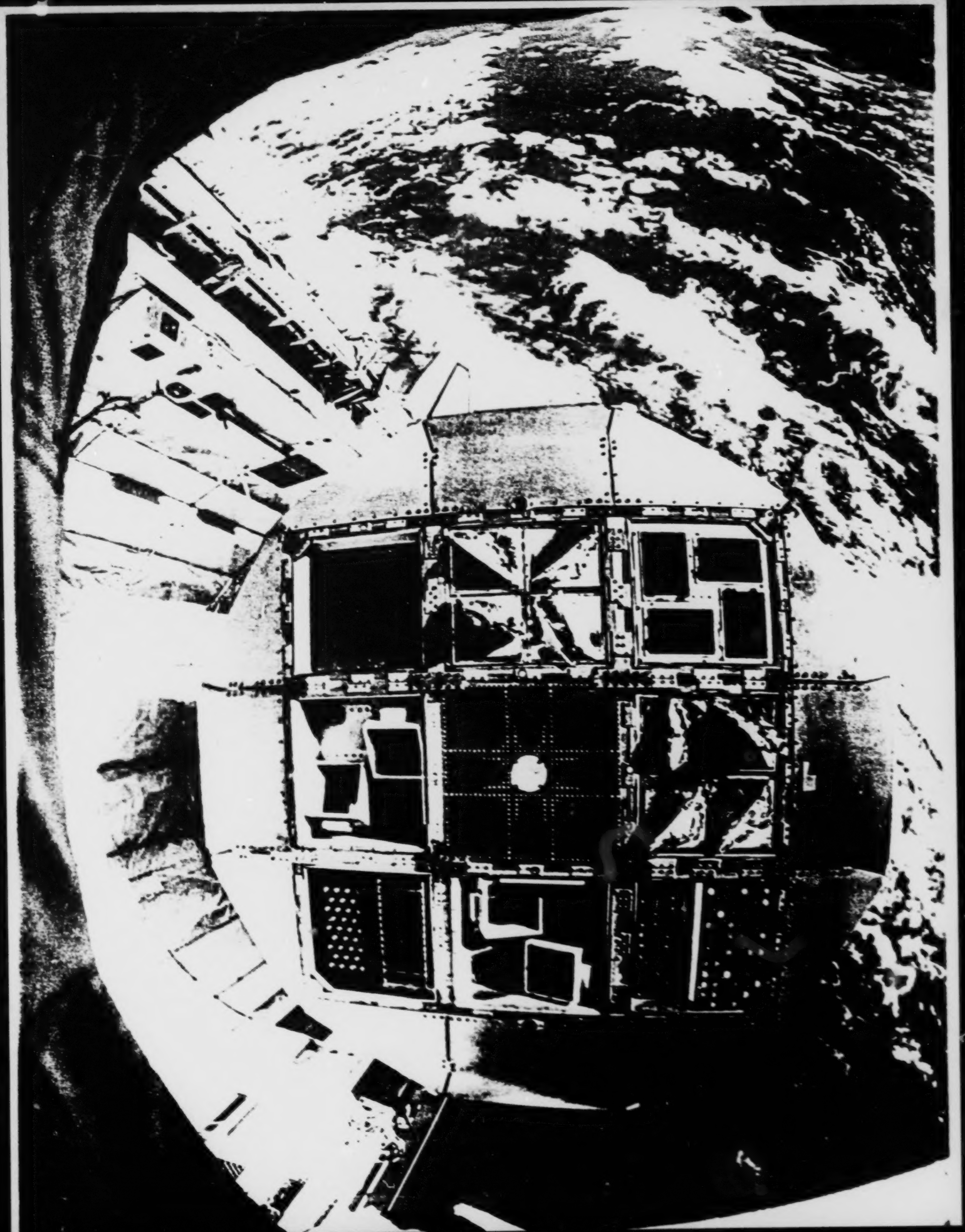
Dr. Marlins served as Director of the SEEDS Project from October 1986, until his death. He promoted the project at national science meetings and in schools throughout the nation. His dream was to see every student from elementary through university have the opportunity for meaningful science experiences. That is the challenge he has left us.

SPACE

Introduction

SEEDS: A Celebration of Science is the final report of an exciting project made available to the academic community by the NASA Headquarters Educational Affairs Division, the NASA Langley Research Center, and the George W. Park Seed Company. The major goal of the project was to stimulate interest in science through the active involvement of all participants. Youthful investigators utilized the basic and integrated science process skills as they conducted the research necessary to complete the data reports used in the compilation of this document. Participants described many unique activities designed to promote critical thinking and problem solving. SEEDS made a significant impact toward enhancing the teaching, learning, and enjoyment of science for students worldwide.

Dr. Robert W. Brown
Director
Educational Affairs Division
Office of External Relations
NASA Headquarters



Foreword

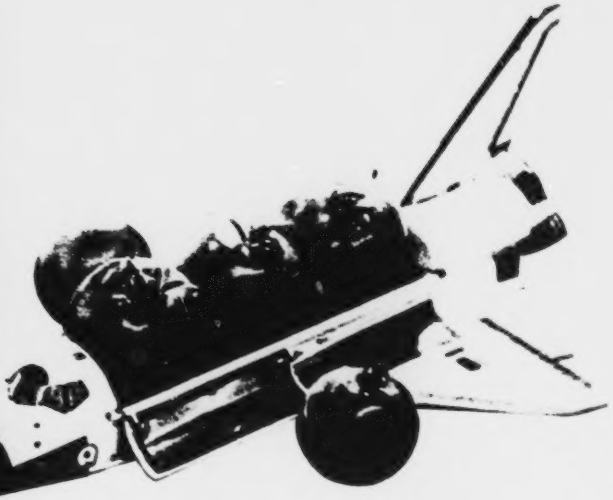
How does one go about telling the story of one of the world's largest science projects? Far from a dry, analytical work, *SEEDS: A Celebration of Science* attempts to capture the spirit of adventure apparent in every teacher and student researcher involved with the project. It discusses the successes and failures, puzzles and solutions inherent in scientific problem solving. But there was another side to the project that made it especially attractive to young and old researchers around the world. It was a more romantic notion: an opportunity to be a part of the vital history of this country, to collect data for NASA! What could be as thrilling? Perhaps writing about it.

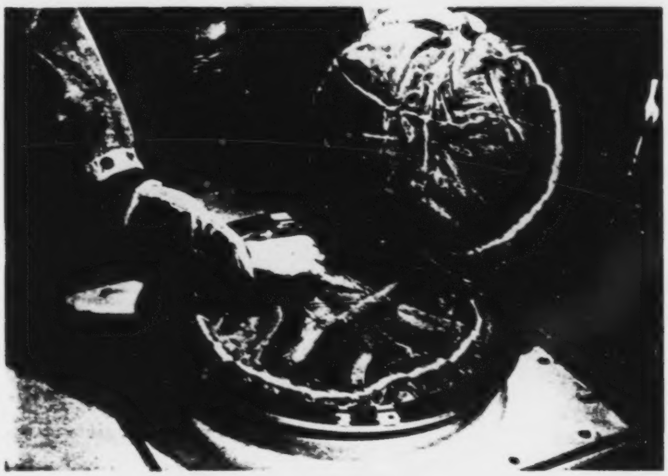
The ticket to this great adventure was a SEEDS (Space Exposed Experiment Developed for Students) kit obtained from NASA after the flight of Space Shuttle Mission STS-32 in January of 1990. Each SEEDS kit was a complete package for starting the experiment and reporting results. Inside the envelope was a resource guide for teachers, a letter from the United States Department of Agriculture, a press release for local use by the SEEDS teacher, an appropriate number of space-exposed and Earth-based seed packages, and a data reporting form that was to be mailed to the NASA/AESP office at Oklahoma State University, where SEEDS Project data were to be compiled. The data reporting form was familiar to the educators who would use it because it was similar to the optical scan testing forms that are so common in standardized testing. This form, however, had one important difference. It contained an essay question. On page 8, the last question of the form asked data reporters to describe any notable difference in mature fruit produced by Earth-based and space-exposed seeds. Of interest to those destined to read these reports was the number of other comments supplied with this anecdotal data. Almost every one of the nearly eight thousand report forms mailed back contained comments from the reporters about their feelings concerning the project. Equally surprising in a program of this size was that virtually all reporters described what the project had meant to them and their classes and thanked NASA for giving the students of the United States (and the world) the chance to participate.

Rather than give an account of these comments, it might be best if they are allowed to describe themselves. As you read the anecdotal and hard data found in *SEEDS: A Celebration of Science*, you will find many comments from teachers, students, and parents. From them you will see the impact this project had on science education in this country.

The rescue of LDEF after 5 3/4 years in space. Note the tattered foil tray coverings.

The crew of the space shuttle Columbia for Mission STS-32.





"This project jibed well with our science curriculum, and as part of math lessons it generated many useful graphs. Since we also do a great deal of writing in our first grade, the students also wrote wonderful stories— from factual journals to imaginative fiction about the aliens in the seeds! I personally particularly enjoyed the SEEDS project because it was REAL— not the teachers and not NASA know the results! That is so unlike the rest of our mundane science experiments where we contrive projects to prove what we already know. ...Your contribution makes both teaching and learning more exciting and relevant."

—Madbury, NH (elementary)

Top left: Technicians removing the SEEDS tray from LDEF.

Above: Dacron bags containing tomato seeds are placed into SEEDS canisters.

Right: Packets containing space-exposed seeds.

The Great National Science Project

The SEEDS project has become more than another clever acronym used by scientists and engineers. Space Exposed Experiment Developed for Students (SEEDS) has become one of the great national science projects. This cooperative effort along many fronts brought the students of America into the scientific community to experience the excitement, the interaction, the hope, and the disappointment that is the nature of science.

NASA, in cooperation with the George W. Park Seed Company of Greenwood, South Carolina, developed SEEDS to be one of the projects to be sent aboard the first mission of the reusable LDEF (Long Duration Exposure Facility) satellite. The Park Seed Company had tested the effects of launch and re-entry forces on seeds during a "Get-Away-Special" experiment aboard Space Shuttle Mission STS-6 in 1983. LDEF is a cylinder 9.1 m (30 ft) long and 4.3 m (14 ft) in diameter and weighing 9979 kg (11 tons). The unique open-grid structure of LDEF allows it to accommodate a total of 86 experiment trays that are 96.5 cm (34 in) wide and 127 cm (50 in) long. Each tray can accommodate any number of totally self-contained experiments that can be arranged around the circumference of the satellite or on either of the two ends. Designed to be placed in orbit by the space shuttle, LDEF is three-axis stabilized when free flying in space; therefore, experiments can be flown on LDEF so they can measure the effects of space exposure with respect to any surface orientation because the sides of the satellite maintain the same position relative to Earth.

For the first LDEF mission NASA selected 57 experiments, which were the work of 200 investigators from 33 private companies, 21 universities, seven NASA centers, nine Department of Defense laboratories, and eight foreign countries. The experiments were organized into four categories: (1) materials, coatings, and thermal systems; (2) power and propulsion; (3) science; and (4) electronics and optics. SEEDS was designated experiment P0004-2 and was placed in tray F-2 near the trailing edge of the LDEF, next to the end pointed toward space. Sharing this experiment tray was experiment P0004-1, Seeds in Space, designed by Dr. Jim Alston and George W. Park, Jr. of the Park Seed Company, and experiment P0006, Linear Energy Transfer Spectrum Measurement Experiment, designed by Eugene V. Benton of the University of San Francisco and Thomas A. Parnell of the Marshall Space Flight Center. The Seeds in Space experiment was designed to test the effects of long-term space exposure on a variety of seeds. The Park scientists tested two million seeds representing 120 varieties, 106 species, 97 genera, and 55 plant families. Most of these seeds were flown in a 1 cubic dm (1/3 cubic ft) sealed aluminum canister, 30.4 cm (12 in) in diameter and 10.2 cm

(4 in) deep, painted white and located in tray F-2. The covering dome of the canister was only .127 cm (.050 in) thick. Two smaller, vented canisters were also filled with seeds and flown. One was painted white for thermal control and located next to the larger canister on the exterior surface of the experiment tray; the other was painted black and located on the back of the tray to test the internal environment of LDEF. The Linear Energy Transfer Spectrum Measurement Experiment was designed to measure the energy deposited per unit path length of a charged particle as it passes through matter. This passive detector gathered measurements on the amount of shielding required to prevent penetration by charged particle impacts.

On October 19, 1983, the 12.5 million tomato seeds used in the SEEDS project were packed into five sealed experimental canisters under 101 kPa (14.7 psi) pressure and 20% relative humidity. The canisters were identical to the large canister used for experiment P0004-1, and each was filled with four Dacron bags of seeds as well as thermoluminescent passive dosimeters between each layer and a passive thermometer for recording maximum temperature. The canisters were placed into the F-2 tray. After assembly, the tray was transported to the Kennedy Space Center where it was covered with a Teflon thermal blanket and loaded onto the LDEF on January 19, 1984.

The experimental phase of SEEDS began on April 6, 1984, when the Space Shuttle *Challenger*, Mission 41-C, was launched with LDEF on board. The next day, LDEF was placed in orbit for what was projected to be a one year mission. However, with mission delays and the *Challenger* disaster placing the entire Shuttle program on hold, LDEF began to live up to its Long Duration name. Placed into orbit at an altitude of 475 km (295 mi), LDEF's orbit began to decay more rapidly than expected as increased solar activity expanded Earth's atmosphere and increased the drag on the satellite. As mission delays and rescheduling continued to push back a date for LDEF's retrieval, the satellite's altitude began to decrease rapidly. Finally, on January 12, 1990, LDEF was rescued by the crew of *Columbia* during Mission STS-32 at an altitude of 342 km (219 mi). Astronaut Bonnie Dunbar operated the Remote Manipulator System to capture LDEF and positioned it for Astronaut Marsha Ivins to make an extensive photographic assessment of the satellite and each of its experiments.

After returning to Edwards, California, on January 20, 1990, LDEF was ferried with the shuttle back to the Kennedy Space Center where the entire satellite underwent a series of tests and evaluations. The first experimental tray was not removed from LDEF until February 23, 1990. The tray was F-2, the SEEDS tray. From the Kennedy Space Center, the tray was transported by minivan the next day to the Park Seed Company in Greenwood, South Carolina. That evening, the first canister was weighed and then opened to extract a small number of seeds for germination tests. By 9 p.m., the tests had started. By 3 p.m. the next day, the first signs of germination, radi-

"What a fantastic, motivational learning experience! Seeds from space. Thank you. Thank you. Thank you. Thank you."

—St. Petersburg, FL. (secondary)

cle emergence, had occurred in many of the seeds. This was nearly 30% faster germination than found in Earth-based seeds. The rest of the canisters were not opened until March 1, 1990, when a news conference and formal container opening was held. Again, each canister was weighed to verify that no moisture had escaped; then the canister was opened and seeds were removed to begin germination testing. As with the first canister, the same pattern of 18%-30% faster germination was observed in the space-exposed seeds.

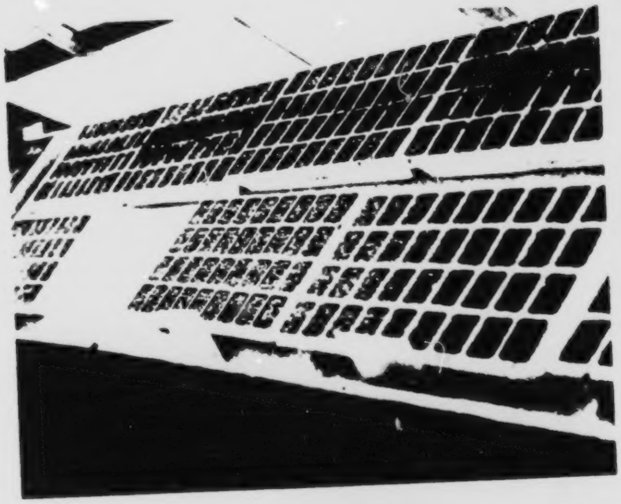
The Park Seed Company staff then began to rapidly assemble and distribute the SEEDS kits to the nearly 60 thousand teachers who had requested kits up to that time. The Park Seed packaging facility quickly packaged the space-exposed and Earth-based seeds (which had been kept in Parks' controlled environment of 21°C, 101 kPa (14.7 psi), and 20% relative humidity) in Parkspack® foil packets. Park employees and a local Greenwood handicapped citizens group then assembled the kits for mailing. The elementary school kits contained an instructional manual, an activity book, a data collection booklet, a press release for local use, a letter from the United States Department of Agriculture, a packet of 50 Earth-based seeds, and a packet of 50 space-exposed seeds from all four Dacron bags in one of the canisters. The secondary school kits contained similarly written materials with three foil packets of seeds. One packet contained 50 Earth-based seeds, another contained 25 space-exposed seeds from layers A and B of one canister, and the third contained seeds from layers C and D of the same canister. The college kit contained written materials similar to those developed for the other levels of kits, plus five seeds packets: one packet of 25 seeds from each of the four layers in a canister and a packet of 50 Earth-based seeds. The first kits were mailed March 7, 1990, and the rest of the 121,207 kits (three and a half tractor-trailer loads) in the initial mailing left Park Seed Company within the following two weeks.

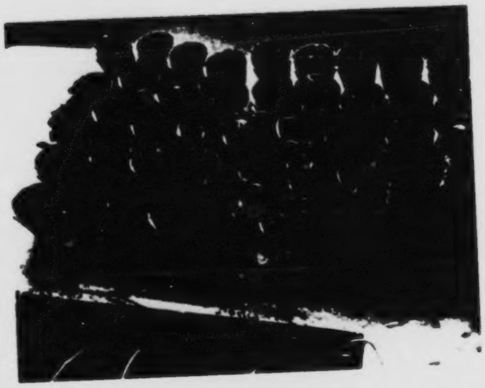
In all, more than 132,000 kits were mailed from Park Seed Company and NASA to 64,000 teachers and 3.3 million students in 40,000 schools in all 50 states, the District of Columbia, and 30 foreign countries. Thus the stage was set for one of this country's greatest science learning projects. NASA Administrator Admiral Richard Truly summed up NASA's hopes for SEEDS when he said, "Because this is the first opportunity for long-duration exposure of living tissues, every classroom experiment will be significant. I hope millions of students will experience this hands-on, one-of-a-kind experiment and learn that science is fun."

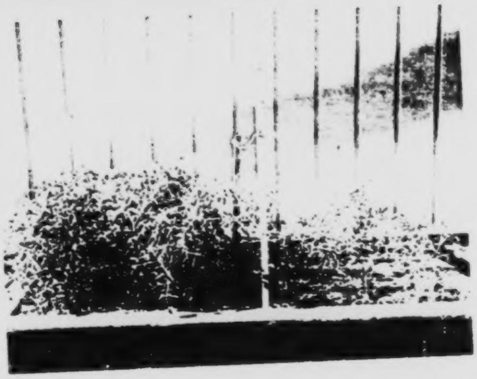
"I never realized when I began this project that it would be so rewarding for me as a teacher, but also for my first grade students, the city of Belleville, the St. Louis metropolitan area, our family, and our many friends. I am now referred to as the 'tomato teacher'..."

—Belleville, IL, (elementary)

Germination and growth experiments.







Mutant Ninja Tomatoes

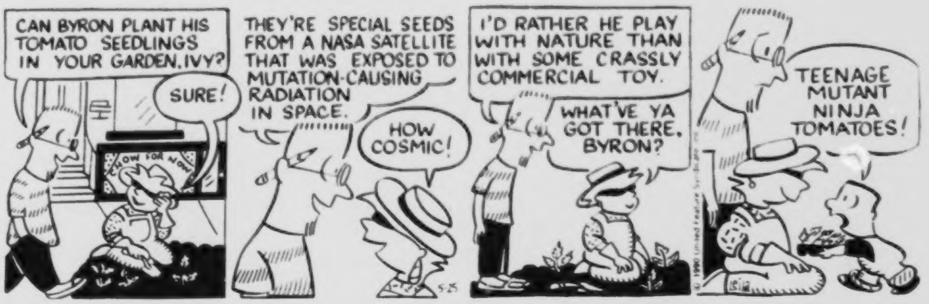
The great national science project was, in many young minds, a search for mutations. Visions of *Attack of the Killer Tomatoes* and its sequel were probably running through the minds of many of the young scientists as they began SEEDS. Realistically, such large-scale changes were not likely to occur in a variety as genetically stable as Rutgers California Supreme, but it was likely that in a test as large as SEEDS some variation from normal would be observed.

To look for these possible changes, most researchers chose to use the test procedures outlined by NASA in the SEEDS kit. These procedures were designed to provide researchers who had limited horticultural experience with the ability to successfully conduct germination and growth observations. In most cases, researchers started their sets of seeds in small containers. Styrofoam cups, milk cartons, small plastic pots, or peat pellets were commonly used, while those with access to more sophisticated equipment often used germination trays filled with sand, vermiculite, or potting soil.

Many different observations were reported concerning the germination of the seeds. Some observations concerned a single plant in each test set that would be afflicted with a certain condition. Several reports of plants emerging root first, or with three, four, or no cotyledons fall into this group. Most descriptions of germination concerned rates exhibited by the different categories of seed. Although there were *many* occurrences in which Earth-based seeds germinated sooner than space-exposed, the overall data reported suggests the space-exposed seeds germinated at a slightly faster rate.

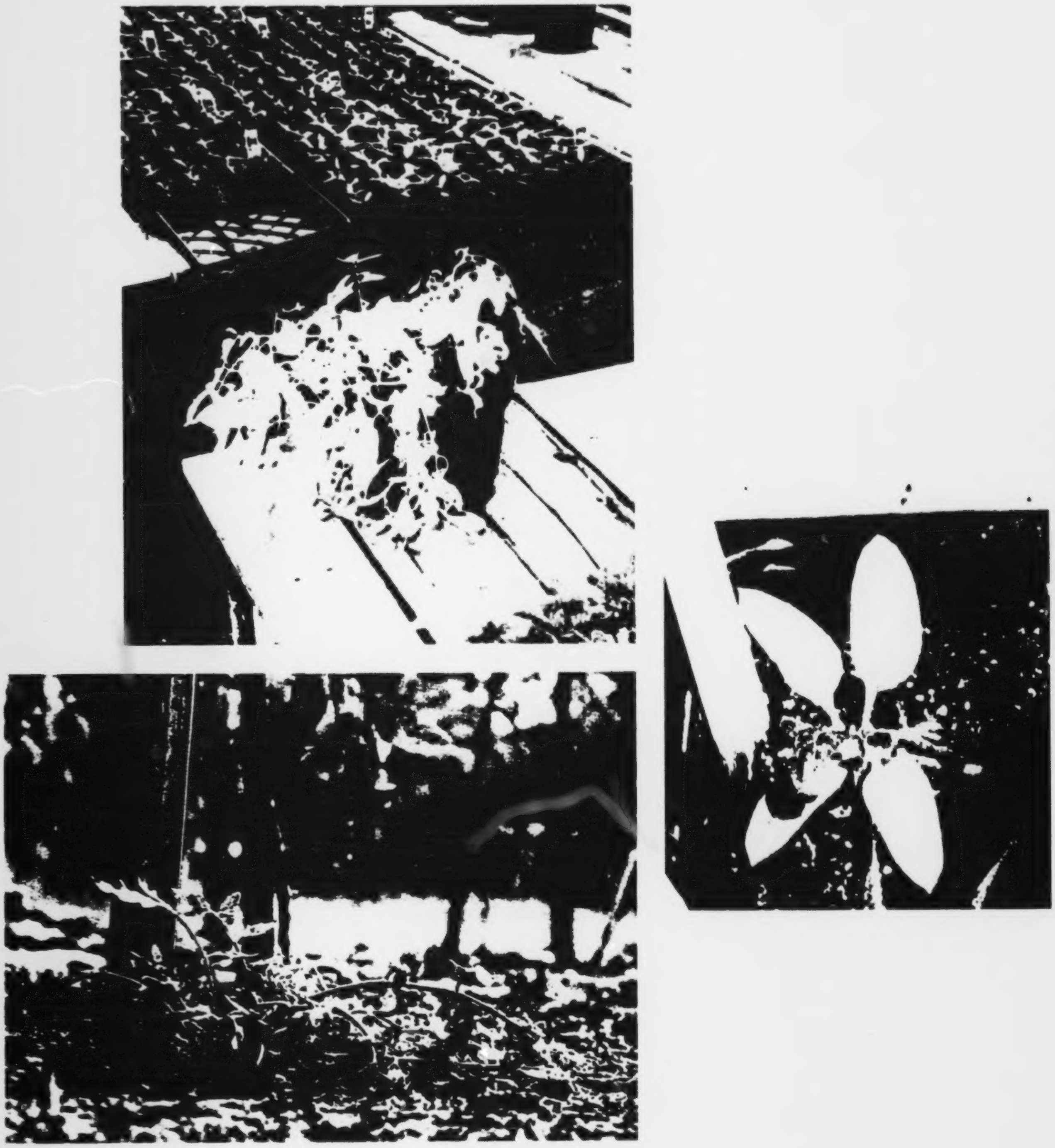
As growth proceeded, the variety of observations increased. Again, though there were exceptions, the overall data suggests that space-exposed seedlings (called spacelings in one report) have a faster initial growth rate. In most cases, this faster growth was observed for the first three or four weeks of growth. Eventually, the Earth-based seedlings caught up with their high flying counterparts and overall, no differences were found between the two types of plants or their fruit.

Many researchers reported a number of interesting observations. Differences in plant size, leaf shape and size, stem and leaf color, odor (or lack thereof), root size, stem thickness (a very common reporting), resistance to heat and cold, resistance to drought, leaf position on stems, and resistance to pests were noted. One plant produced fruit from a flower with a variegated calyx which bore seeds that in second generation studies produced albino plants. Interestingly enough,


CAN BYRON PLANT HIS TOMATO SEEDLINGS IN YOUR GARDEN, IVY?
SURE!
GROW FOR NOW
THEY'RE SPECIAL SEEDS FROM A NASA SATELLITE THAT WAS EXPOSED TO MUTATION-CAUSING RADIATION IN SPACE.
HOW COSMIC!
I'D RATHER HE PLAY WITH NATURE THAN WITH SOME CRASSLY COMMERCIAL TOY.
WHAT'VE YA GOT THERE, BYRON?
TEENAGE MUTANT NINJA TOMATOES!

MISS FEATHERBEE by Leila Cabib; © 1990 United Features Syndicate. Used with permission.

Some of the mutations reported in space-exposed plants.



The original Teenage Mutant Ninja Tomato.

a normal calyxed flower on the same plant bore seeds producing green plants. Many accounts were recorded of space-exposed plants being untouched or slightly nibbled while their Earth-based neighbors were consumed by deer, caterpillars, robins, rabbits, or ants. Among the individual space-exposed plant variants were albino individuals, stunted plants, a plant with two stems attached to a single root, a plant that produced no upward stem growth so all its leaves arose from a central point, a plant with no leaves, and seeds from a particular layer A-B plant that turned dark blue when washed and dried. Very few irregular Earth-based plants were reported.

Researchers left no doubt about their feelings when they reported on the "space" fruit: "Tastier!", "Juicier!", "Sweeter!", "Cans nicely!", "Thicker skin!", "Superior!", "Perfectly round and vibrantly red!", "Darker!" "Smoother texture!" "More meat!", "More seeds!". Fruit production garnered similar comments: "Five times more fruit!", "Fruit releases easier from stem!", "Earlier!", "Had tomatoes coming out of my ears!", "Made enough Gazpacho for a week!", "Used two bushels for sauce!"

Some researchers accepted NASA's challenge to be creative and designed a number of experiments to glean as much information as possible from this program. Centered primarily in colleges and high schools around the country, these self-designed experiments extracted much information that may show the effects of long-term space exposure on seeds. In addition, the experiment allowed many youthful investigators the opportunity to experience scientific inquiry firsthand. This kind of open-ended questioning and exploring is exactly what the originators of SEEDS had in mind when they designed the project.

Some of the researchers used the SEEDS project to begin long-term research on such topics as space seed histology, chromosome morphology, and cell cycle time of the space-exposed plants and their descendents. Others designed experiments to test hypotheses associated with the space-borne generation. Studies of the bacteria found on the seed coats of the space-exposed seeds found that several species of *Bacillus* as well as a lactose fermenting bacteria and unidentified fungi species were present. Tests of fruit pH found no difference between space-exposed and Earth-based plants. Space-exposed plants also performed normally in tests of geotropism, tissue culturing, seed weight, and phototropism.

Three student-designed experiments discovered information that may provide clues to the enhanced performance of space-exposed seeds observed by many researchers. Several of the chromatography tests that were performed found space-exposed plants had greater levels of chlorophylls and carotenes than the Earth-based plants. In addition, light absorbance tests found that light absorbance was greater in extracts made from space-exposed plant tissues. Finally, results from laser-induced fluorescent spectroscopy led a team of researchers to conclude that space-exposed seeds exhibited premature chlorophyll development, possibly a partial explanation for the space seedlings rapid initial growth.

Taken together, the results of student research give remarkably good news to NASA. Even though many student researchers were disappointed not to see drastically altered mutant plants and fruit, we now know seeds *can* survive in space for long periods of time with little or no change in the resulting plant. This apparent fact was the fuel for much discussion in classrooms across the country. To take the results of these experiments and interpret meaning is the essence of scientific discourse. One group of young elementary school researchers and their adult mentor in Pennsylvania did just that and projected their results to mean that not only is space not a harmful place for seeds, but it may be a safe place for long-term seed storage. Acknowledging the precarious situation of the genetic heritage embodied in many of the world's endangered plants, as well as the constant potential for agricultural disasters that could lead to famine on a worldwide scale, these researchers propose long-term storage of wild and agricultural seeds in space, secure from unpredictable environmental factors on Earth.

"All in all, the project was fun, exciting, enlightening, and very educational. I'm a sucker for success. We're doing it again!"

—Tacoma, WA. (elementary)

Cosmic Rays and Stray Basketballs

One of the aims of SEEDS was to grow plants in a variety of environments under a variety of conditions. NASA wanted this information to help determine the hardiness of space-exposed seeds. However, in many places, the amount of hardiness required for tomato plants to survive went beyond the bounds of living organisms. As one respondent put it, "Never before in the history of horticulture have more plants been subjected to more stress."

For the most part the tomato seeds were safe— until their packet was opened. At that point some seeds found their way to the floor or unintentionally mixed with other seed types. Most seeds successfully made their way into starting containers to await other hazards. In elementary classrooms the major hazard was too much love. From teacher accounts and growth data, many seedlings apparently suffered from overwatering. Many researchers reported seedling growth for three or four weeks followed by a period of dormancy and mass plant death. A teacher from Texas wrote that in her classroom it was feast or famine; plants were either totally neglected or watered to death. Another teacher said she used Vitamin B to try to revive her class' overwatered test subjects. Other seedlings suffered from the axiom of "if a little is good, more must be better." Over- fertilizing killed or stunted many seedlings. A teacher from Kansas explained that after her class' plants died she discovered one of her students was secretly giving the plants vast quantities of Miracle-Gro® plant food.

Even without experiencing "tough love," most researchers reported their discovery that tomato growth definitely has its limitations in classrooms. Tomato plants require good exposure to light in order to grow well. The many reports of weak-stemmed, spindly seedlings are a good indicator that in most cases, classroom lighting was not sufficient for the seedlings. Tinted and polarized classroom windows, classrooms without windows, classrooms with windows blocked by construction projects, and school energy conservation programs that required lights to be turned off during nonuse hours all hampered seedling growth. And then there were the plants that got too much light, when the light fixture fell on them!

SEEDS originators designed the project to be "hands-on." Teachers know such methods are the best way to teach science. To give children the opportunity to touch, feel, and explore their world is as much an intellectual exercise as a tactile one. Such work contains risk. Lab work is messy, the outcomes are often quite unpredictable, and students frequently cause damage to materials with which they are working. But quality experiences come about when students participate in quality science. SEEDS had all of these rewards and hazards, especially to the plants. As

"Our children were eager NASA scientists, fascinated with the concept of space tomatoes, and rewarded not only by their satisfaction coming from the completion of an independent scientific search, but also by the realization of working on a national project with unknown results. They felt part of something really important, and had an introduction to scientific methodology as well. Thank you for this unique and wonderful opportunity! You have provided the children with a special and well designed experience which they'll always remember."

—Boston, MA, (parent)

seedlings, the plants were at high risk for damage. In good, active, inquiring classes, this risk was maximized. One teacher stated she never imagined the project would be so traumatic. Each day brought her a new litany of mishaps to unfortunate plants. Tomato plants were broken during measuring and watering; other plants were broken when transplanting. Entire starting flats were dropped, elbowed, fallen into, dumped, tipped, vandalized, or stolen. One of the seed flats in a Kentucky classroom was found, too late, in a toy chest where a child had placed it. A student in London, Ontario, wrote this about his SEEDS experience:

> "Dear NASA: Hi. My name is Matt. I am in grade 2. I really enjoyed growing my plants. Here are my results. My Earth seed did not grow. My space seed grew but it fell off my desk. It died."

Other plants experienced trauma while being transported. Plants from a San Diego classroom were destroyed when the teacher, who was transporting them to her home, became involved in a traffic accident. A teacher in Arlington, Texas, found her class' plants cooked when she returned two hours after she had left her broken-down car to seek aid. Another set of seedlings was lost when they fell off a school bus while a student was carrying them home.

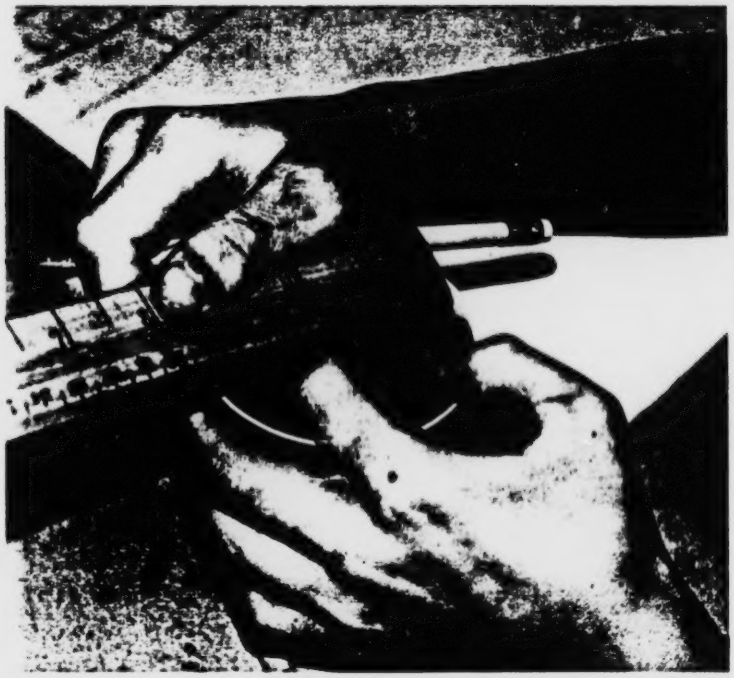
Rutgers California Supreme is a variety known to be relatively slow growing when compared to the many varieties of hybrid tomatoes on the market. As a result, most teachers found if the increasing size of the tomato seedlings was not yet a factor, then the upcoming end of the school year required that the seedlings be transplanted to gardens. Those tomatoes that had somehow managed to survive the rigors of a classroom were now "graduated" to the real world, to experience what the Victorians characterized as "nature red in tooth and claw."

Natural disasters of all kinds began to befall the plants. In fact, a kind of international weather history can be obtained from the reports. Hailstorms hit Iowa, Alberta, New Jersey, Ontario,

Students with much loved plants.

"The radiation above the atmosphere over a period of six years is negligible when compared to the danger of a small classroom where over 100 students come and go and check and water plants."

—Bowling Green, KY, (secondary)



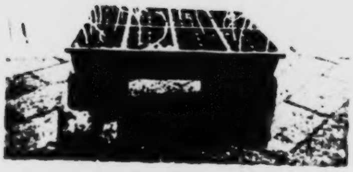
Seedling measurement can be hazardous!

New Mexico, and Virginia. Heavy rains inundated Texas, Kentucky, North Carolina, Illinois, Northern California, Florida, and New Jersey. A late freeze struck Indiana and Washington. It was the middle of winter in Australia and the rainy season in Guam. High heat withered plants in Kansas, Texas, California, Arizona, and Florida. Thunderstorms destroyed plants in St. Louis and in the Bronx. Floodwaters drowned space tomato plants in Iowa and Illinois. Tornadoes blew through Illinois and Missouri. Many of these weather conditions happened to the same gardens. In North Texas, for example, if the unusually heavy rains in late spring didn't get the plants, then the dryness and high temperatures of late June and July did. At the Most Precious Blood School in Corpus Christi, Texas, plants were washed out by a storm, replanted, overwatered, damaged by wind, and attacked by ants. There were no survivors. Of course, there were natural disasters that topped all the others. In Kentucky, a school was struck by lightning and all the school's contents, tomatoes included, were destroyed by the resulting fire. In the Philippines, two typhoons followed by a killer earthquake eliminated the SEEDS project at Buena Vista Elementary School.

Experienced gardeners expect to battle various pests during a particular growing season. In fact, pest management is viewed by some to be part of the challenge in being a successful horticulturist. Usually, gardeners in particular regions of the country have a normal group of tomato pests to deal with each year. The SEEDS project provided an informal means to catalog the kinds of pests that tomatoes attract.

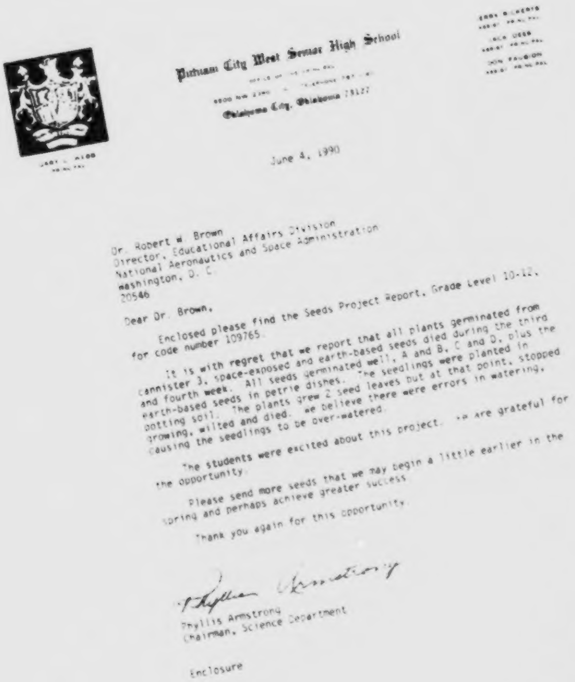
Many researchers found the usual assortment of aphids, cut worms, tomato horn worms, white flies, ants, nematodes, and mealybugs eating on their plants. In addition, many observers reported damage by rabbits, deer, groundhogs, opossums, raccoons, birds, snails, and mice. One mouse dug and ate only the space seeds from their germination trays. He was reported to be alive and well and still pestering his resident classroom despite the best laid traps.

Apparently some animals exhibited a preference as to the type of plants they would eat. In some gardens only the Earth-based plants would be eaten; in a few others, space-exposed plants seem to be the cuisine of choice. Cockroaches in one Florida garden seemed to eat only Earth-based leaves, while a cat in Arizona preferred space-exposed leaves. Other animals exhibited no preference at all. Two gerbils in one elementary classroom escaped from their enclosure and ate 24 newly planted experimental seeds. Because the female was pregnant at the time and half of the consumed seeds were space-exposed, the students advanced the possibility that she might deliver Teenage Mutant Ninja Gerbils. A stray dog in Wisconsin was repeatedly attracted to the tomato plants in a teacher's yard or at least the Dixie cups that contained them. Another dog, this time a teething puppy, wins the prize for lack of preference. He ate the tomato plants, soil and all!



Disaster!

Tiny green caterpillars ate our plants. We took them home for some tender care.



Putnam City West Senior High School

Oklahoma City, Oklahoma 73127

June 4, 1990

Dr. Robert W. Brown
Director, Educational Affairs Division
National Aeronautics and Space Administration
Washington, D. C.
20546

Dear Dr. Brown,

Enclosed please find the Seeds Project Report, Grade Level 10-12, for code number 109765.

It is with regret that we report that all plants germinated from cannister 3, space-exposed and earth-based seeds died during the third and fourth week. All seeds germinated well, A and B, C and D, plus the earth-based seeds in petrie dishes. The seedlings were planted in potting soil. The plants grew 2 seed leaves but at that point, stopped growing, wilted and died. We believe there were errors in watering, causing the seedlings to be over-watered.

The students were excited about this project. We are grateful for the opportunity.

Please send more seeds that we may begin a little earlier in the spring and perhaps achieve greater success.

Thank you again for this opportunity.

Phyllis Armstrong

Phyllis Armstrong
Chairman, Science Department

Enclosure

The tomatoes were not even immune from family and friends. One teacher's husband inadvertently mixed seedling types when he transplanted them to the garden, thereby terminating data collection. Another mistook the tomatoes for weeds and proceeded to mow them down. Parents were no more trustworthy. One student reported her parent stepped on the plant while another reported his plant was a casualty to the lawnmower.

A parent in Portland, Oregon wrote that his stepson found his space voyager plants were not even safe from his four-year-old stepsister's "Michael Jordan 3-point shot" when it rebounded and severely damaged both of his space-exposed plants. Miraculously the plants survived and later produced a tomato that won the Youth Division Vegetable Oddity Blue Ribbon at the Oregon State University Extension Service Harvest Fair. "Despite bombarding gamma rays and a stray basketball, his experiment was a total success." Finally, a teacher in Delta, Ohio, related this great story about what can happen if you allow a friend to help weed your garden:

> "...It was truly an accident and she felt horrible about it. In fact I wish I had had a camera. She was so proud of herself at first; and then, when I said they weren't weeds, but our science experiment. Oh well, I guess you had to be here. I've never seen a woman move that fast planting!"

Tomato plants were not the only project participants that experienced difficulties during the spring and summer of 1990. A program the size of SEEDS was bound to involve people with personal difficulties and tragedies. Several teachers wrote letters apologizing for missing data that would have been collected had they not been preoccupied with other details such as personal illness or family illness or death. The fact that these people took the time to write and explain what had happened to their SEEDS data is a testament to their dedication and caring.

Good Scientists Don't Eat Their Experiments

One of the more interesting and unexpected occurrences during the project was the media attention surrounding the possibility of radiation-induced mutations in the space-exposed tomatoes. As explained in the SEEDS Teacher's Guide, the effects of long-term radiation exposure was one of the chief variables of the experiment. But when a *Los Angeles Times* article warning of a possibility of poisonous fruit from the space- exposed plants appeared shortly after the seeds were distributed, many teachers and students found the experiment had taken on an added dimension.

Radiation emission is a process that occurs naturally in many elements. The atoms of these substances release excess energy as they transform to a lower energy form of the same element or change into a different element. Such energy-emitting materials are termed radioactive in that they release energy in the form of waves, particles, or photons. On Earth, there are many natural sources of radiation. This "background radiation" comes from soil, building materials, rocks, groundwater, food, and even our own bodies! Man- made sources also contribute to our "background" radiation exposure. Smoke detectors, computer terminal screens, and medical X-rays are among these sources.

For objects in Earth orbit, the degree of radiation exposure often depends upon the satellite's altitude and the length of time it is in space. At an altitude of approximately 400km (250 miles), the Shuttles and LDEF fly in Low Earth Orbit. This altitude avoids exposure to the major radiation belts that girdle Earth; however, the satellites are still subject to galactic cosmic radiation and significant doses of radiation exposure from a band of radiation known as the South Atlantic Anomaly. The dosimeters placed inside the SEEDS canisters indicated during their five and three-fourths years in space that seeds directly under each canister dome received 720 rads of radiation exposure. Upper layers of seeds worked to shield lower seeds in each canister so the dosimeter under the layer D seeds received but 350 rads of radiation.

The major effect of radiation on living tissues most often comes from high energy particles, such as alpha particles. This form of radiation has the capability of penetrating structures such as the SEEDS canister and, upon entering the seeds, can collide with and alter the structure of atoms and molecules. Such collisions may lead to a disruption of vital chemical and physical processes as well as change the DNA of the seed. This possible DNA change was the subject of the initial *Times* article. Changes in DNA caused by radiation are usually point mutations because they alter that DNA molecule at a single base pair site along a strand of the molecule. The changes that can result are by no means predictable. In the vast majority of cases, such alterations in DNA are lethal, at least to the cell that contains the affected strand of DNA. Other changes that can occur include changes in the resulting tissue's physiology or morphology. In the space-exposed seeds, such somatic mutations would affect only the resulting plant and would not be passed on to the plant's descendents. Other mutations might affect the reproductive tissues. Depending on the cells affected, these germ cell mutations could be

"I saw this was an excellent opportunity to add new importance to teaching standard 7th grade concepts like measuring, data collection and analysis, and forming hypotheses and conclusions."

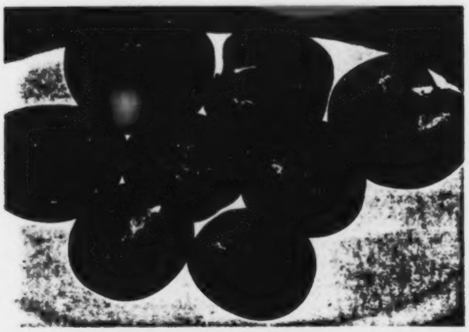
—Endicott, NY.
(secondary)

passed on to subsequent generations, but it would take at least two generations before such a mutation could be confirmed. All living organisms are subject to mutations. Some are induced by the various mutagens present in the environment, such as solar radiation and exposure to chemicals. Others arise spontaneously due to errors in DNA replication, seeming to occur at more or less consistent rates within the gene pool of a particular organism. In all, some 700 different kinds of mutations are known to occur in tomatoes.

Tomatoes are a domesticated member of the family Solanaceae, a large group of plants that includes potatoes, eggplant, and the various types of poisonous nightshade plants. They attain their poisonous nature from toxic alkaloids that may occur throughout the plant or in selected locations of the plant such as the roots or the fruit. Though the likelihood of a mutation stimulating the production of toxic alkaloids in the space-exposed tomatoes was extremely remote, it was the contention of the *Los Angeles Times* article that such a possibility did exist. In reality, such a mutation cannot be ruled out, but it seemed unlikely that it would result during the space radiation exposure of only 12.5 million seeds. It is more likely that such a mutation would occur (given the number of tomato plants grown worldwide and the cumulative amount of background radiation and other mutagens these plants are exposed to each growing season) to normal Earth-bound seeds. Nevertheless, the *Times* article added a new realm to the experiment that would have been missed had the article not been published.

For most teachers, the possibility of changes in the fruit stimulated much discussion in their classes. No longer were students looking for grossly mutated plants. Now there was real discussion about radiation, its effects on living tissues, what the probabilities of mutation occurrence were, and why scientists could not completely rule out the possibility that such changes had occurred. Many attempted to resolve the problems by taking them into their own hands and performing tests on the plants and their fruit.

Tomato tasting



Lower right. The tedious task of removing seeds for second generation studies.

In several schools, radiation tests were conducted. Early tests performed by NASA that showed no radioactivity in the seeds were confirmed by students, teachers, principals, health departments, and hospitals. In Little Falls, New York, students began researching the effects of radiation on plants even before their space-exposed seeds arrived. They irradiated groups of cherry tomato and radish seeds with shortwave ultraviolet light for three, six, and nine hours.

Others chose to perform animal testing of the fruit. One school tested pigs because their digestive tracts are so similar in structure and function to that of humans. The pigs ate space-exposed tomatoes exclusively and showed no ill effects. One pig later won Grand Champion at a hog show. Various cats, dogs, and rodents also became test consumers of the fruit, but all were volunteers for the service and ate without human encouragement or permission. Rosary College in River Forest, Illinois, chose to take the direct approach and tested ethanol extracts from the flesh of space-exposed tomatoes for the presence of toxic alkaloids. The extracts were placed on a spot plate and tested using the Lieberman test (5% sodium nitrite in concentrated sulfuric acid). The space-exposed fruit extracts showed no reaction, but extracts made from the fruit of the bittersweet nightshade, *Solanum dulcanara*, gave a pronounced orange-brown color.

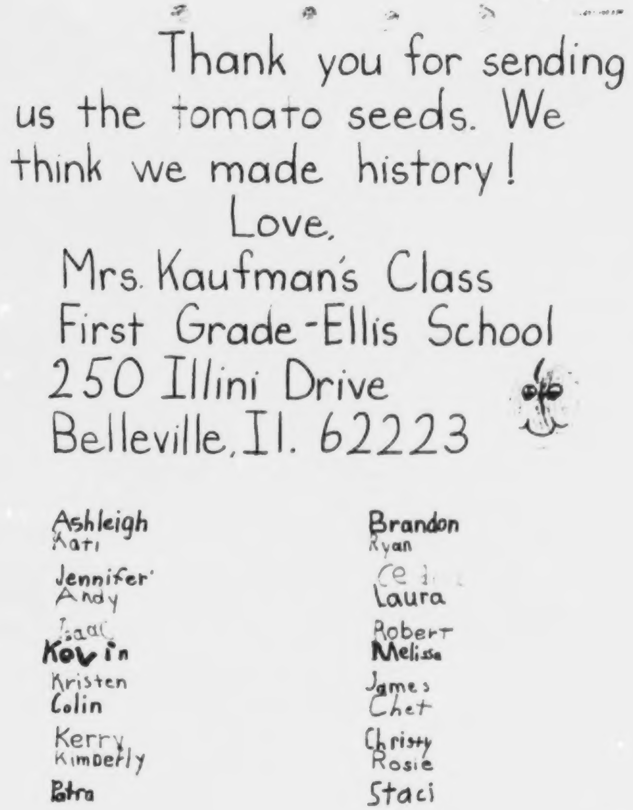
Despite advice from Dr. Jim Alston, head of research at Park Seed Company, that "A good scientist doesn't eat the experiment," many chose to eat the space-exposed tomatoes anyway. Those most willing to do so seemed to be the consultants from the community, many of whom were longtime tomato growers and eaters. Many of the families who had nurtured the plants after their children had brought them home for the summer reported they had eaten and enjoyed the tomatoes. Many teachers also reported they enjoyed eating the space-exposed tomato fruit. One teacher planned to make tomato jam to give as Christmas presents, and another reported her family had been eating the tomatoes for several weeks and no one in the family glowed.

Though most teachers were able to use the "negative" media attention to their advantage and open the doors to new discussions and new student explorations, not all were able to overcome the controversy that came about in their schools. Some superintendents and principals, fearing the possibility of civil liability, discouraged work with the seeds, prohibited students from taking the space-exposed seedlings, or had the plants destroyed. A few teachers returned SEEDS kits, fearing they might be radioactive. One high school teacher reported that a few people would not go near the space-exposed seedlings in her class due to fear of radiation.

Overall, the media attention about possible radiation-induced mutations in the space-exposed seeds had very little negative effect on the SEEDS Project. In most cases, teachers saw the attention as a good way to stimulate thinking and discussion about the experiment, teach concepts of radiation and radioactivity, and develop understanding of genetics and mutations. It opened areas of reasoning that might not have been explored otherwise. An elementary teacher in San Antonio, Texas, may have described it best when she reported, ". . .the experiment and the media flap produced much discussion about radiation, mutation, and the like. We feel the experience was very beneficial to the students."

"We learned through the process that science is not easy. We learned that it takes many tries before something really good may actually occur. That is why we performed so many experiments, to try to increase our chances of finding something new. But if nature has it that nothing new is obtained from our tries, we do not consider it a failure, we consider ourselves one step closer in our search for information."

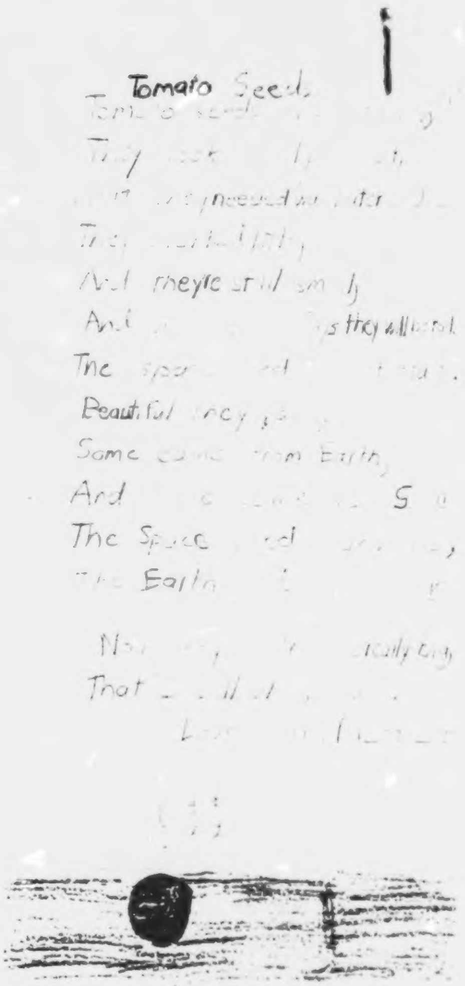
—St. Paul, MN,
(secondary)



Thank you for sending
us the tomato seeds. We
think we made history!
Love,
Mrs. Kaufman's Class
First Grade-Ellis School
250 Illini Drive
Belleville, Il. 62223

Ashleigh
Kati
Jennifer
Andy
Isaac
Kevin
Kristen
Colin
Kerry
Kimberly
Petra

Brandon
Ryan
Cedric
Laura
Robert
Melissa
James
Chet
Christy
Rosie
Staci



Tomato Seeds
Tomato seeds [illegible]
They [illegible]
[illegible] they needed [illegible] water [illegible]
They [illegible]
And they're still small
And [illegible] they will [illegible]
The space [illegible]
Beautiful they [illegible]
Some came from Earth
And [illegible]
The Space [illegible]
The Earth [illegible]

Now [illegible] really big
That [illegible]
Love [illegible]

A poem, note, and newsletter produced by students.

THE
N.E.W.S.
(THE NEWSPAPER ON EXPERIMENTS WITH S.E.E.D.S.)
VOLUME 1, ISSUE 2 May 2, 1990 FOR THE GOOD OF ALL

So Far...

An Interview With the 5th and 6th Grades

The NASA Story

"If you ever have such a great activity or research plan again, please contact my school district."

—Pampa, TX. (student)

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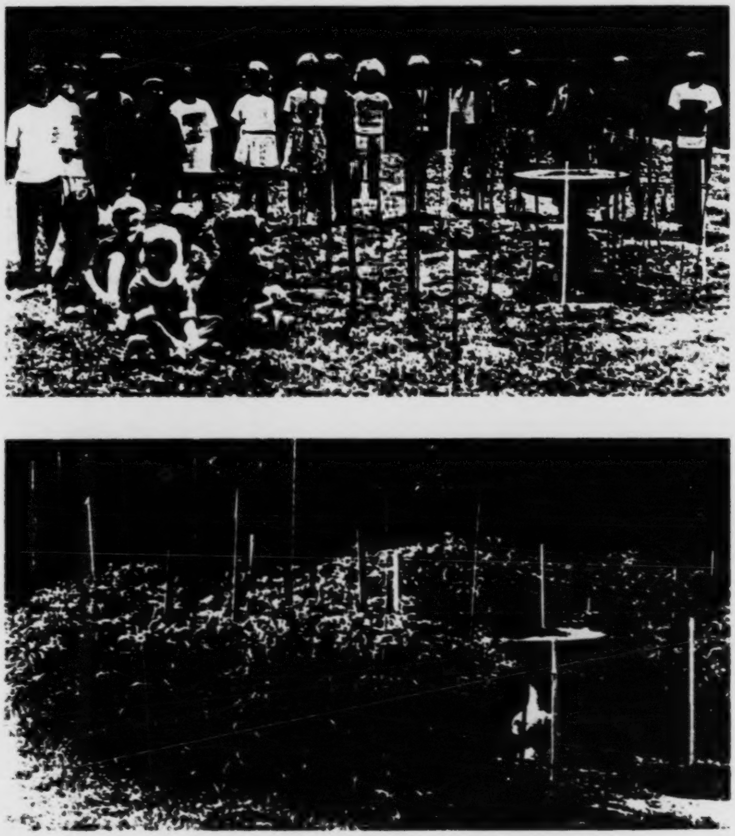
The World's First Bacon, Lettuce, and Space Tomato Sandwich Party

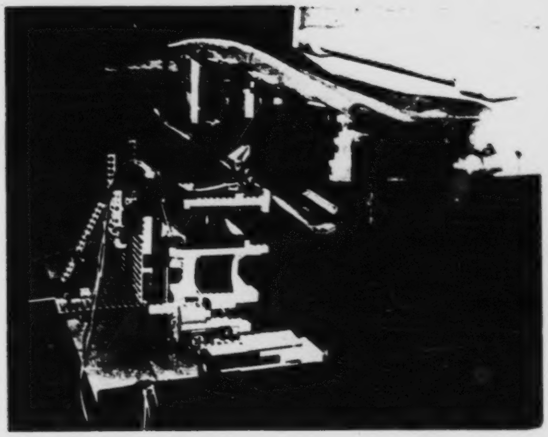
A science project this large is bound to cause excitement. Obviously, a few million space-exposed seeds loose in the country are going to attract some bit of attention. Add to this circumstance thousands of creative teachers and several million bright, inquisitive, youthful minds, and you have all the ingredients for a first-class extravaganza with the potential to capture the hearts and minds of people throughout the world. It is little wonder that SEEDS generated so many wonderful and innovative experiences for children and adults.

SEEDS was originally designed to involve students from fifth grade through college. One of the surprises for its developers was the number of preschool and primary classes that participated. Teachers found SEEDS to be an ideal way to introduce measuring techniques and to help students learn about the "birth" of plants. Primary students can also be excellent predictors and problem solvers, explaining their hypotheses by way of pictures and determining what information they want to obtain and how they should best go about collecting that information. Many early elementary students wrote poems and stories about their experiences; some even wrote and performed plays, including of course, Mr. McGregor and Peter Rabbit! A first grade teacher at Ellis School in Belleville, Illinois, gave her students tomato-shaped pages on which they wrote compositions titled "If I Was a Tomato." (Most would be pizza sauce.) Some primary classrooms collaborated with fifth grade "mentors", who aided their younger schoolmates and learned more than just science. Students from a fifth grade class in Greenbelt, Maryland, wrote this account of their experience as teachers:

> "...We were the teachers helping the first graders learn about growing stuff. We had them draw pictures of what they thought the tomatoes would look like first and kept them in a file. Boy, did we laugh at the crazy ideas they had!"

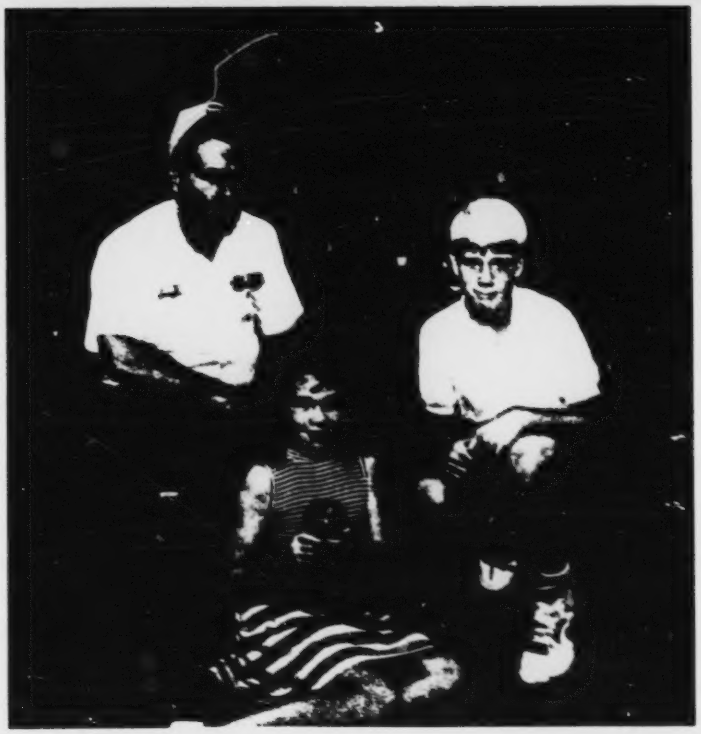


One class and it's "Great Space Tomato Adventure" garden.



Grobot automatic plant misting system.

Some "space" tomatoes were champions!



"Thank you for involving young people in this great national science project. I hope you can involve students in another project that will help spark their enthusiasm and rekindle their desire to learn."

—St. Peters, MO.

(elementary)

Many projects utilized experts from the community.

SEEDS was utilized in elementary schools in truly innovative ways. It became a whole school project in many places. Teachers modified the project not only to generate the data needed by NASA, but to make the project meaningful and real for each of their students. Many teachers of various special education classes used SEEDS to help their students practice thinking skills, problem solving, graphing, measuring, and communicating. A mother who homeschools in New York used SEEDS with her two daughters, one of whom is multi-handicapped. Other teachers used SEEDS to stimulate the creative abilities of gifted students. Sixth grade students at Robert Grove Elementary in Tulsa, Oklahoma, designed, constructed, and programmed "Grobot", an automatic plant misting machine which they built for their SEEDS project. A teacher at Gardendale Elementary in Merritt Island, Florida, utilized local resources and arranged a mentorship program for her gifted students with a specialist in biotechnology at EPCOT Center. Most of the activities with SEEDS were more mundane, but equally important. Learning about controlling variables, observing, predicting, discussing results, making mistakes, cooperating with others, and gaining an awareness of the role of science in their lives are the real gains of an opportunity like SEEDS. A teacher in Attica, Indiana, summed it up in the following:

> "Measurements were truly student done— with misunderstandings and errors no doubt abundant (such as what constitutes a leaf for measuring). . . . I get many comments indicating interest and awareness; people are continually noticing and reporting newspaper accounts of others' results, etc. It makes some of us feel good to participate in such a notable project."

Secondary schools and colleges also developed unique approaches to SEEDS. Nebraska City High School researchers took their project on the road to allow students at junior high and elementary schools to observe and make predictions. An East Texas State University professor produced a newsletter and distributed seeds to an area high school and to interested university students and faculty. Mayo High School in Rochester, Minnesota, buried a SEEDS packet as a part of a time capsule to be opened on the fortieth Earth Day, April 22, 2010. Students in the elementary science methods classes at the University of Tennessee in Knoxville learned the meaning of "hands-on science" when they collected SEEDS data for NASA. Northern Virginia Community College-Manassas students maintained a SEEDS project display in the library and kept interested parties informed via the *Tomato Post* newsletter. But SEEDS was not wholly owned by science classes. At Woodron Middle School in Edison, New Jersey, students combined science, language arts, and civics to write a journal from the perspective of a journey through time and space of a DNA molecule as it is developed in the body of an Earth-bound plant, underwent laboratory experimentation, was instrumental in the economic growth of New Jersey, journeyed to Chile, was selected for space travel, endured the rigors of space for six years, and proved the tenacity of life by returning to Earth even more vigorous than before. The art classes at Massachusetts Bay Community College collected SEEDS data although their instructor admitted, "Art classes were not as efficient or systematic as we might have been."

In many places, SEEDS became a celebration that moved beyond the scope of a science project for students and became a project that touched entire communities. Needless to say, many local newspapers published stories about SEEDS and local schools' involvement. Many people in communities became closely involved with the program either through displays and entries at local fairs (where many "space tomatoes" won prize ribbons), or through actual growth of plants in

CALLAWAY - A GREAT PLACE
TO LEARN
APRIL 9 PTO
SITE OF NASA RESEARCH
PROJECT

Working for NASA!

their personal gardens. One technique used by many project teachers was to contact a local tomato "expert" and use that person's garden for summer transplant of the seedlings. The expertise of these community resource people undoubtedly saved many tomato plants that otherwise would have perished at the hands of so many novice gardeners.

Local community organizations were also involved in the program. Local businesses donated materials to schools. A Veterans Administration hospital, senior citizens groups, and nursing homes all became home for school-germinated tomato seedlings. Some organizations became SEEDS project sites in their own right. A SEEDS kit was received by the greenhouse manager for New Ventures Inc. of La Grange, Georgia. New Ventures, a nonprofit rehabilitation facility for developmentally disabled individuals, had few problems gathering data since their principle product is hydroponically grown tomatoes. The gardening class at the Muskegon Correctional Facility in Muskegon, Michigan, also received a SEEDS packet. The gardening instructor, himself an inmate at the facility, reported they did pretty well with the project but they kept losing students, due to transfers and paroles. The Kennedy Space Center (KSC) became a SEEDS location as did most other NASA sites. The Technical Training Department for Lockheed Space Operations Company at KSC reported over 120 plants were adopted by interested employees and five plants were grown on-site. Plants were also grown hydroponically at the KSC Exploration Station, a NASA learning center.

Ken Selee and students being photographed by ***National Geographic.***

Some places became fully engaged in the SEEDS celebration of science and made the project an excuse for an actual celebration. The teachers and students who participated in SEEDS in the state of Delaware were recognized during the June 1st "Delaware Tomato Recognition Day." In Franklin, Wisconsin, students took home "birth" announcements to commemorate the germination of their seeds. In Lewisville, Florida, students were brought together at the end of summer to have a SEEDS reunion where they reported data and shared accomplishments. Many locations held end-of-summer tomato tasting parties. The tasting party at East Texas State University combined tomato tasting and data collection with pizza, some late evening astronomy, and watching *Attack of the Killer Tomatoes*. A good time was had by all.

Ken Selee, a teacher in Turlock, California, is representative of so many other great teachers in this country in his ability to build excitement in school and throughout his community. Selee saw SEEDS as a way to excite students about the space program while they learned good science.

He organized seeds distribution throughout Turlock public schools, wrote frequent update newsletters to keep every school coordinated, arranged formal "adoptions" of tomato plants by students, and developed special events to inform the public of his students' successes. His classes were the subject of a CBS *Evening News* report as well as a *National Geographic* article and a Discovery Channel feature. Selee's congressman even read a report about Turlock Public Schools' SEEDS project into the Congressional Record. Knowing that good weather conditions present in California would probably hasten maturity of his class' tomato plants, Selee created excitement by "racing" the nation to produce the first ripe space tomato. To celebrate their accomplishment, the classes organized the world's first Bacon, Lettuce and Space Tomato Sandwich Party which was held July 5, 1990. Garth Hull, Center Educational Programs Officer for NASA's Ames Research Center attended the gathering and Selee shared the occasion with the community through the local media. In all, Selee's hard work involved more than 500 people in SEEDS. He eventually served over 2500 space tomatoes and even sent a box of them to NASA Administrator, Admiral Richard Truly.

The story of Ken Selee's participation in SEEDS is only an example of some of the ways the "Space Tomatoes" were embraced by the world. The project quickly became much more than simply an opportunity for students to learn science, although that was justification enough. SEEDS moved out from schools through publicity and involvement into the communities to become an experience shared by nonschool people. It became a celebration of science and learning and an experience most will never forget.

Celebrating science.

DATA

The following pages present data collected from almost 8,000 SEEDS Project Reports returned to NASA by participating investigators. After the initial tables, which present summary data for the project across all grade levels, the data is reported by grade level in an order that approximates the questions in the project report for that grade level. Question 1 asked for the identifying number from the mailing label and required no data treatment. The presentation of data for grades 5-9 begins with two tables summarizing growth data. The tables are followed by data from questions 3 and 4 of the report form before data from questions 2, 5, 6, 7, 8, 9, 10, and 11 are reported *by canister*. Canisters 2, 3, 4, 5, and 7 were used for the Seeds project; Canister 6 held experiment P0004-1, while canister 1 was a backup for SEEDS and did not fly. Data from questions 12 through 14 concerning the temperature and humidity of the growing environment were not included in this report because the information was only relevant to individual projects. Information from question 15 is then correlated with questions 2 through 11. Tables constructed using data collected from questions 16 through 19 indicate the nature of the schools and classes that participated in SEEDS. Information from question 20 regarding the number of students who participated is presented at the end of the report. The same format is used for data from grades 10-12 and colleges.

It is worthwhile to note some of the problems inherent in data collected for a project of this magnitude. Many SEEDS participants, for one reason or another, did not return the data collection forms. Others returned forms that were only partially completed. In many cases this gap could be attributed to lack of reportable results or confusion concerning data that didn't quite match the questions on the form. For example, how would a nonschool organization answer questions concerning classroom structure and school system enrollment? Other discrepancies could occur due to confusion over what information was being requested. It is also obvious that errors did occur in completing the forms. The possibility that the optical scanner reading the data from the reports did not pickup all items should not be overlooked.

Any shortcomings in data reporting should not overshadow the primary value of SEEDS. Students from all over the world contributed data and learned about science from an experimenter's viewpoint. The data collected is secondary to the success of SEEDS as a project of learning and doing. With that perspective in mind, readers of *SEEDS: A Celebration of Science* are encouraged to continue the learning possibilities with the SEEDS data. Many of the possible data treatments were purposely omitted so teachers and students could use SEEDS data to build their own correlations or to use as raw material for instructional units. We sincerely hope the learning from SEEDS will continue for many years to come and will not end with this presentation.

"The part that excited my students the most was a sense of pride in knowing they were doing the same thing as students in all parts of the country. It provided great opportunities to study about diversities and similarities in lots of different areas, and still feel a sense of real unity as Americans."

—Brockpoint, NY.
(elementary)

Data, All Grades

The table displays a summary of data from all canisters of space- exposed seeds and from all grade levels. The information was compiled from questions 5 through 11 of the SEEDS report form. Consistent throughout the report are data indicating a higher percentage of plants producing fruit than producing flowers. One possible explanation is many investigators may have reported fruit production for only those plants producing flowers and not for the total number of plants.

Questions 5-11: **Space-exposed Summary, All Grades, All Canisters**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	7931	66.3	23.3	1.0	100.0
Average number of days required for germination within 14 days after planting	7288	8.4	2.6	1.0	14.0
Number of plants measured	4420	18.1	12.5	1.0	88.0
Average height (cm) at 56 days	4679	21.2	9.7	8.0	38.0
Average width (cm) at 56 days	4208	12.0	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	2118	73.4	34.4	1.0	100.0
Average number of days to first flower within 56 days	538	46.7	8.2	28.0	56.0
Percent of plants producing fruit	1849	74.6	34.2	1.0	100.0
Average number of days from planting until first fruit formed on plant	1621	94.3	25.5	35.0	150.0

Questions 5-11: **Earth-based Summary, All Grades**

The table displays summary growth data for Earth-based seeds across all grade levels. The information was compiled from questions 5 through 11 of the SEEDS report form.

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Germination rate: percent of seeds germinated 14 days after planting	7854	64.6	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	7281	8.5	2.7	1.0	14.0
Number of plants measured	4414	18.6	13.3	1.0	99.0
Average height, (cm) at 56 days	4600	20.9	9.7	8.0	38.0
Average width (cm) at 56 days	4160	11.9	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	2106	72.3	34.9	1.0	100.0
Average number of days to first flower within 56 days	524	46.9	8.5	28.0	56.0
Percent of plants producing fruit	1773	76.1	33.0	1.0	100.0
Average number of days from planting until first fruit formed on plant	1570	94.4	25.8	35.0	150.0

"I debated about transplanting the plants myself because I was afraid they would die if mishandled. But then I thought this was a learning experience for children and they should participate in all parts of the project. Therefore I let them experience the transplanting phase of our experiment. We had a great discussion on why some plants survived and some plants died."

—Burtonsville, MD. (secondary)

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Data, Grades 5-9

The upper table on this page displays space-exposed summary data for plants from all canisters for grades 5-9. This information was obtained from questions 5, 6, 7, 8, 9, 10, and 11 of the SEEDS Project Report form. Grades 5-9 data for question 3 appear in the lower table on the page.

Questions 5-11: **Space-exposed Summary, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	6157	65.8	23.9	1.0	100.0
Average number of days required for germination within 14 days after planting	5717	8.4	2.6	1.0	14.0
Number of plants measured	3459	19.1	12.9	1.0	83.0
Average height (cm) at 56 days	3684	20.9	9.7	8.0	38.0
Average width (cm) at 56 days	3273	11.9	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	1726	72.5	34.9	1.0	100.0
Average number of days to first flower within 56 days	396	46.6	8.5	28.0	56.0
Percent of plants producing fruit	1472	72.8	35.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	1295	95.2	25.5	35.0	150.0

Question 3: **Canister Identified on the Space-exposed Seeds Packet, Grades 5-9**

Canister	Number reporting	Percentage
2	1099	19.9
3	1072	19.4
4	1165	21.0
5	1103	19.9
7	1096	19.8

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The upper table displays grades 5-9 summary data for Earth-based seeds. This table corresponds to the upper table on page 28 and is placed for easy comparison. The lower table displays information from question 4 regarding the germination media used by SEEDS researchers in grades 5-9. As the table indicates, the most popular medium for germination was commercial potting soil. Information correlating germination data and seedling growth with the germination media used begins on page 32.

Questions 5-11: **Earth-based Summary, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	6104	64.0	23.9	1.0	100.0
Average number of days required for germination within 14 days after planting	5731	8.6	2.7	1.0	14.0
Number of plants measured	3478	18.5	12.8	1.0	90.0
Average height (cm) at 56 days	3615	20.6	9.6	8.0	38.0
Average width (cm) at 56 days	3251	11.8	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	1736	70.9	35.7	1.0	100.0
Average number of days to first flower within 56 days	385	46.7	8.7	28.0	56.0
Percent of plants producing fruit	1416	74.2	34.1	1.0	100.0
Average number of days from planting until first fruit formed on plant	1268	95.0	25.8	35.0	150.0

Question 4: **Germination Media Used, Grades 5-9**

	Number reporting	Percentage
Own soil mixture	637	10.1
Commercial potting soil	5285	83.3
Moist paper towel/ blotter/ sponge	145	2.3
Other	254	4.0

"Thanks again for your work, especially for encouraging the interest of schoolchildren around the nation. Following an in-depth unit of study about 'space', our kindergartners and their families were delighted to participate in this national science project."

—St. Paul, MN, (elementary)

Questions 2-11: **Space-exposed Summary. Canister 2. Grades 5-9**

The tables on these two pages compare the canister 2 space-exposed plant growth with Earth-based plant growth. Because both sets of data were reported by the same researchers, the data from the control plants are reported on page 31 as data from canister 2 experimenters. As with the tables on the preceding four pages, these tables display data from questions 5, 6, 7, 8, 9, 10, and 11 of the Seeds Project Report and are placed for easy comparison between the experimental and control data. In addition, data from question 2 related to the number of seeds planted by researchers are reported. The next eight pages present this same growth data correlated for the type of germination media used. Only grades 5-9 data will be correlated in this manner because it was the most abundant and complete data in these categories.

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	1079	38.6	16.0	3.0	230.0
Germination rate: percent of seeds germinated 14 days after planting	965	65.1	23.6	1.0	100.0
Average number of days required for germination within 14 days after planting	909	8.4	2.5	1.0	14.0
Number of plants measured	549	18.7	12.3	1.0	64.0
Average height (cm) at 56 days	632	21.4	10.1	8.0	38.0
Average width (cm) at 56 days	529	11.7	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	343	72.3	31.6	1.0	100.0
Average number of days to first flower within 56 days	78	45.6	8.1	30.0	56.0
Percent of plants producing fruit	231	71.6	35.6	1.0	100.0
Average number of days from planting until first fruit formed on plant	211	92.6	25.9	35.0	150.0

Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1078	38.9	16.1	2.0	195.0
Germination rate: percent of seeds germinated 14 days after planting	957	63.4	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	895	8.7	2.5	1.0	14.0
Number of plants measured	620	17.1	12.3	1.0	64.0
Average height (cm) at 56 days	635	20.8	9.5	8.0	38.0
Average width (cm) at 56 days	531	11.6	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	306	70.9	34.2	1.0	100.0
Average number of days to first flower within 56 days	70	45.8	8.9	28.0	56.0
Percent of plants producing fruit	226	73.3	34.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	208	92.4	26.9	35.0	150.0

"The children have been most enthusiastic about this outstanding science lesson. It has certainly been a high point in our school year. Not only were we able to generate an interest in scientific investigation, which was our primary goal, we were able to integrate reading and math skills into activities related to the SEEDS project."

—Rochester, NY. (elementary)

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An interesting pattern in the data is found on this page. As can be seen throughout all the data tables, the number of reporting investigators decreases as one reads down the table from "Number of seeds planted" to "Average number of days to first flower". The flowering data was the most poorly reported in the project. Though this information was not reported by most investigators, documentation of fruit production, a related event, was relatively well recorded.

Questions 2-11: **Space-exposed Summary, Canister 2, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	115	36.6	14.2	4.0	75.0
Germination rate: percent of seeds germinated 14 days after planting	113	63.9	24.6	1.0	100.0
Average number of days required for germination within 14 days after planting	103	8.2	2.5	1.0	14.0
Number of plants measured	56	18.1	14.2	1.0	64.0
Average height (cm) at 56 days	54	23.4	9.1	8.0	38.0
Average width (cm) at 56 days	51	13.1	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	37	87.6	26.8	1.0	100.0
Average num[illegible] of days to first flower within 56 d[illegible]	8	46.6	10.8	30.0	56.0
Percent of plants producing fruit	31	83.1	28.5	1.0	100.0
Average number of days from planting until first fruit formed on plant	32	91.8	26.3	38.0	126.0

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Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	116	38.0	15.7	4.0	96.0
Germination rate: percent of seeds germinated 14 days after planting	114	60.7	24.4	1.0	100.0
Average number of days required for germination within 14 days after planting	103	8.6	2.5	4.0	14.0
Number of plants measured	53	18.8	13.8	1.0	64.0
Average height (cm) at 56 days	54	23.4	9.5	8.0	38.0
Average width (cm) at 56 days	52	12.7	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	37	84.7	27.2	19.0	100.0
Average number of days to first flower within 56 days	8	42.8	10.6	28.0	54.0
Percent of plants producing fruit	29	83.2	28.5	12.0	100.0
Average number of days from planting until first fruit formed on plant	30	92.8	27.7	38.0	132.0

"Your inclusion of us in this project gave us a chance to practically apply skills used in all subject areas. Knowing that we, just as you, were providing vital data for this experiment gave us a feeling of pride in all our work.

. . . We hope you will continue to include students, as scientists, in future projects."

—Sheffield Lake, OH, (elementary)

Questions 2-11: **Space-exposed Summary, Canister 2, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	852	39.8	16.3	3.0	230.0
Germination rate: percent of seeds germinated 14 days after planting	807	64.7	23.3	1.0	100.0
Average number of days required for germination within 14 days after planting	763	8.4	2.5	1.0	14.0
Number of plants measured	478	18.9	12.1	1.0	59.0
Average height (cm) at 56 days	505	21.1	10.2	8.0	38.0
Average width (cm) at 56 days	447	11.6	4.7	4.0	16.0
Flowering rate: percent of plants producing flowers	229	71.7	33.7	1.0	100.0
Average number of days to first flower within 56 days	57	45.5	8.1	30.0	56.0
Percent of plants producing fruit	185	71.8	35.1	1.0	100.0
Average number of days from planting until first fruit formed on plant	173	93.2	26.1	35.0	150.0

Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	850	40.0	16.3	2.0	195.0
Germination rate: percent of seeds germinated 14 days after planting	799	63.2	23.6	1.0	100.0
Average number of days required for germination within 14 days after planting	751	8.7	2.5	1.0	14.0
Number of plants measured	489	18.4	12.3	1.0	62.0
Average height (cm) at 56 days	502	20.9	9.9	8.0	38.0
Average width (cm) at 56 days	437	11.7	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	213	71.7	35.1	1.0	100.0
Average number of days to first flower within 56 days	52	45.6	8.9	28.0	56.0
Percent of plants producing fruit	181	72.7	34.8	1.0	100.0
Average number of days from planting until first fruit formed on plant	171	94.4	26.1	35.0	150.0

"Despite our problems and limitations, it was a valuable learning experience. It was exciting to think that we were a part of a national effort through NASA. And it was thrilling to see growth from a seed!"

—St. Louis, MO. (elementary)

Questions 2-11: **Space-exposed Summary, Canister 2, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	40	31.9	14.4	5.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	8	70.5	30.2	6.0	98.0
Average number of days required for germination within 14 days after planting	8	7.6	3.2	4.0	13.0
Number of plants measured	3	24.7	5.5	19.0	30.0
Average height (cm) at 56 days	29	20.9	10.3	8.0	38.0
Average width (cm) at 56 days	7	9.6	4.7	4.0	16.0
Flowering rate: percent of plants producing flowers	32	72.7	18.5	30.0	100.0
Average number of days to first flower within 56 days	5	44.6	8.9	31.0	52.0
Percent of plants producing fruit	8	31.5	31.9	1.0	80.0
Average number of days from planting until first fruit formed on plant	4	113	25.9	77.0	132.0

Questions 2–11: **Earth-based Summary, Canister 2 Experimenters, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4); Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	40	33.6	13.5	12.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	9	56.1	35.9	6.0	90.0
Average number of days required for germination within 14 days after planting	7	8.1	3.5	5.0	13.0
Number of plants measured	31	9.8	10.4	3.0	55.0
Average height (cm) at 56 days	30	17.7	3.2	8.0	28.0
Average width (cm) at 56 days	11	9.5	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	22	66.9	27.1	1.0	100.0
Average number of days to first flower within 56 days	6	47.7	8.7	30.0	53.0
Percent of plants producing fruit	9	60.3	33.7	3.0	93.0
Average number of days from planting until first fruit formed on plant	5	84.4	52.9	40.0	142.0

> ***"Thank you very much for involving my students in this scientific experiment. Although the differences in growth rates, flowering rates, plant characteristics, and fruit production were not as significant as hoped for, my students enjoyed designing, observing, and conducting their experiment. This was a very worthwhile project for my students. Their interest in science increased and their knowledge of the experimentation process blossomed."***
>
> —New Hope, MN. (elementary)

Questions 2-11: **Space-exposed Summary, Canister 2, Using Other Germination Media (Question 4), Grades 5-9**

As indicated in the question 4 discussion, most researchers used commercial potting soil for germinating their tomato seeds. Very few of the investigators using alternative methods, however, shared their secrets concerning the identity of "other" germination media. It is assumed that those who wrote about germinating in water, hydroponic solutions, garden plots, and burned soil from the Yellowstone forest fires indicated "other" on their report forms.

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	55	33.9	13.4	11.0	66.0
Germination rate: percent of seeds germinated 14 days after planting	47	69.2	22.1	4.0	98.0
Average number of days required for germination within 14 days after planting	46	8.2	2.5	4.0	14.0
Number of plants measured	27	14.8	10.1	3.0	36.0
Average height (cm) at 56 days	32	24.6	10.7	8.0	38.0
Average width (cm) at 56 days	25	12.5	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	19	71.6	30.6	8.0	100.0
Average number of days to first flower within 56 days	3	48.7	1.5	47.0	50.0
Percent of plants producing fruit	7	51.3	42.0	4.0	100.0
Average number of days from planting until first fruit formed on plant	9	100.2	30.7	55.0	135.0

Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	55	33.5	13.5	9.0	62.0
Germination rate: percent of seeds germinated 14 days after planting	47	66.1	21.0	6.0	95.0
Average number of days required for germination within 14 days after planting	44	8.9	2.6	4.0	13.0
Number of plants measured	34	12.9	9.7	2.0	38.0
Average height (cm) at 56 days	32	22.2	9.2	8.0	38.0
Average width (cm) at 56 days	27	12.3	4.9	4.0	16.0
Flowering rate: percent of plants producing flowers	13	71.9	38.9	1.0	100.0
Average number of days to first flower within 56 days	3	52.3	1.5	51.0	54.0
Percent of plants producing fruit	8	46.5	34.7	3.0	100.0
Average number of days from planting until first fruit formed on plant	9	90.0	35.1	35.0	120.0

"Thank you for giving our science classes the opportunity to participate in such a worthwhile experiment. It was a hands-on activity which generated much enthusiasm in the class. Without a doubt, the children learned and felt that they were contributing to science."

—Londonderry, NH.
(elementary)

Questions 2-11: **Space-exposed Summary, Canister 3, Grades 5-9**

The next ten pages present another series of tables concerning data from a single canister. As with canister 2, canister 3 data are first presented as a summary based upon questions 2, 5, 6, 7, 8, 9, 10, and 11 of the SEEDS Project Report. The summaries of experimental and control data are then followed by correlations that compare the same factors as they relate to the germination media used. This information is repeated for canisters 4, 5, and 7 on pages 50 - 79.

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	1052	40.4	15.5	2.0	152.0
Germination rate: percent of seeds germinated 14 days after planting	1033	65.4	23.4	1.0	100.0
Average number of days required for germination within 14 days after planting	956	8.5	2.6	1.0	14.0
Number of plants measured	577	18.6	12.4	1.0	56.0
Average height (cm) at 56 days	594	21.4	9.9	8.0	38.0
Average width (cm) at 56 days	556	12.1	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	253	72.3	36.7	1.0	100.0
Average number of days to first flower within 56 days	48	48.1	8.2	30.0	56.0
Percent of plants producing fruit	232	72.2	36.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	189	96.8	24.4	40.0	150.0

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1052	40.9	16.4	4.0	153.0
Germination rate: percent of seeds germinated 14 days after planting	1024	63.7	23.7	1.0	100.0
Average number of days required for germination within 14 days after planting	952	8.7	2.6	1.0	14.0
Number of plants measured	569	18.9	12.6	1.0	90.0
Average height (cm) at 56 days	591	20.9	9.8	8.0	38.0
Average width (cm) at 56 days	554	11.9	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	241	74.9	35.0	1.0	100.0
Average number of days to first flower within 56 days	43	48.5	7.1	30.0	56.0
Percent of plants producing fruit	217	74.8	34.7	1.0	100.0
Average number of days from planting until first fruit formed on plant	186	98.3	25.4	38.0	150.0

"They were given exposure to the procedures for properly conducting experiments. They were able to make predictions, collect data, and chart the results. It was an exciting and educational experience for all."

—Franklin, WI. (elementary)

Questions 2-11: **Space-exposed Summary, Canister 3, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min	Max
Number of seeds planted	105	39.9	15.5	2.0	81.0
Germination rate: percent of seeds germinated 14 days after planting	103	66.5	23.1	4.0	100.0
Average number of days required for germination within 14 days after planting	92	8.4	2.5	3.0	14.0
Number of plants measured	54	17.0	12.0	1.0	52.0
Average height (cm) at 56 days	58	22.2	10.1	8.0	38.0
Average width (cm) at 56 days	53	12.4	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	35	73.6	36.5	1.0	100.0
Average number of days to first flower within 56 days	9	49.8	8.5	30.0	56.0
Percent of plants producing fruit	35	69.9	39.9	1.0	100.0
Average number of days from planting until first fruit formed on plant	31	88.1	23.1	52.0	140.0

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	105	38.8	15.4	4.0	79.0
Germination rate: percent of seeds germinated 14 days after planting	101	62.3	24.0	8.0	99.0
Average number of days required for germination within 14 days after planting	91	8.7	2.4	4.0	14.0
Number of plants measured	53	17.1	11.6	1.0	46.0
Average height (cm) at 56 days	58	21.3	10.6	8.0	38.0
Average width (cm) at 56 days	52	12.3	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	34	72.4	37.2	1.0	100.0
Average number of days to first flower within 56 days	4	47.8	11.9	30.0	55.0
Percent of plants producing fruit	31	71.3	38.5	1.0	100.0
Average number of days from planting until first fruit formed on plant	30	91.3	24.7	52.0	140.0

"What a fantastic, motivational learning experience! Seeds from space. Thank you. Thank you."

—Ashland, WI.
(secondary)

Questions 2-11: **Space-exposed Summary, Canister 3, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	893	40.5	15.4	5.0	152.0
Germination rate: percent of seeds germinated 14 days after planting	877	65.1	23.2	1.0	100.0
Average number of days required for germination within 14 days after planting	816	8.5	2.6	2.0	14.0
Number of plants measured	494	18.8	12.2	1.0	56.0
Average height (cm) at 56 days	503	20.9	9.8	8.0	38.0
Average width (cm) at 56 days	475	11.9	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	207	71.7	36.9	1.0	100.0
Average number of days to first flower within 56 days	36	47.9	8.2	30.0	56.0
Percent of plants producing fruit	189	72.1	36.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	152	99.1	24.2	40.0	150.0

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	893	41.1	16.3	4.0	153.0
Germination rate: percent of seeds germinated 14 days after planting	871	63.6	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	814	8.7	2.6	1.0	14.0
Number of plants measured	491	19.1	12.6	1.0	90.0
Average height (cm) at 56 days	501	20.6	9.5	8.0	38.0
Average width (cm) at 56 days	477	11.9	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	197	74.1	35.6	1.0	100.0
Average number of days to first flower within 56 days	37	48.8	6.7	36.0	56.0
Percent of plants producing fruit	178	74.5	34.8	1.0	100.0
Average number of days from planting until first fruit formed on plant	149	100.3	25.0	38.0	150.0

> ***"They were excited about being part of a larger community and showed the beginning of scientific observation of their world.***
>
> ***Working in a school without any formal curriculum or resources in science. I was very glad to have given them this experience."***
>
> —Durham, NH, (elementary)

Questions 2-11: **Space-exposed Summary, Canister 3, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	22	39.1	15.9	12.0	59.0
Germination rate: percent of seeds germinated [illegible] days after planting	22	72.1	26.3	1.0	100.0
Average number of days required for germination within 14 days after planting	19	7.4	3.2	4.0	14.0
Number of plants measured	10	11.8	10.1	1.0	35.0
Average height (cm) at 56 days	11	24.8	10.3	13.0	38.0
Average width (cm) at 56 days	9	13.0	3.9	7.0	16.0
Flowering rate: percent of plants producing flowers	4	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	2	52.0	5.7	48.0	56.0
Percent of plants producing fruit	4	79.5	23.9	50.0	100.0
Average number of days from planting until first fruit formed on plant	3	90.3	19.1	70.0	108.0

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	22	40.1	16.1	12.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	22	61.7	30.6	1.0	100.0
Average number of days required for germination within 14 days after planting	19	8.7	3.1	4.0	14.0
Number of plants measured	7	14.0	8.7	5.0	30.0
Average height (cm) at 56 days	10	24.0	11.5	8.0	38.0
Average width (cm) at 56 days	7	13.4	4.4	7.0	16.0
Flowering rate: percent of plants producing flowers	5	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	1	50.0	--	50.0	50.0
Percent of plants producing fruit	5	81.0	24.1	50.0	100.0
Average number of days from planting until first fruit formed on plant	4	107.0	32.4	71.0	140.0

> ***"The children were able to spend some time collecting data and they also learned that experiments do not always work out as planned. We took time to discuss ideas as to what things we might have to improve to increase the success of our experiment."***
>
> —Lenhartsville, PA (elementary)

Questions 2-11: **Space-exposed Summary, Canister 3, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	30	38.2	15.3	10.0	72.0
Germination rate: percent of seeds germinated 14 days after planting	28	70.3	26.6	4.0	100.0
Average number of days required for germination within 14 days after planting	27	9.1	2.5	2.0	13.0
Number of plants measured	18	19.1	15.8	3.0	49.0
Average height (cm) at 56 days	21	24.9	10.7	8.0	38.0
Average width (cm) at 56 days	19	13.5	4.0	4.0	16.0
Flowering rate: percent of plants producing flowers	6	53.2	41.0	4.0	100.0
Average number of days to first flower within 56 days	2	40.0	2.8	38.0	42.0
Percent of plants producing fruit	4	60.0	30.7	29.0	100.0
Average number of days from planting until first fruit formed on plant	4	71.3	21.3	50.0	98.0

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	30	39.0	15.6	10.0	72.0
Germination rate: percent of seeds germinated 14 days after planting	27	72.9	23.6	6.0	100.0
Average number of days required for germination within 14 days after planting	27	9.3	2.4	4.0	14.0
Number of plants measured	17	19.1	16.1	1.0	49.0
Average height (cm) at 56 days	21	24.4	10.4	8.0	38.0
Average width (cm) at 56 days	18	13.5	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	5	66.2	30.7	22.0	100.0
Average number of days to first flower within 56 days	2	44.5	6.4	40.0	49.0
Percent of plants producing fruit	5	64.0	32.6	22.0	100.0
Average number of days from planting until first fruit formed on plant	5	75.6	22.2	52.0	101.0

"This was a neat project. We made the local news. Since we are a city school, it is tough to make the news except in a negative way. Thanks a lot!"

—Kettering, OH. (secondary)

Questions 2-11: **Space-exposed Summary, Canister 4, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1149	40.4	16.0	1.0	150.0
Germination rate: percent of seeds germinated 14 days after planting	1122	67.9	23.8	1.0	100.0
Average number of days required for germination within 14 days after planting	1050	8.4	2.5	1.0	14.0
Number of plants measured	646	20.1	13.0	1.0	71.0
Average height (cm) at 56 days	656	20.9	9.7	8.0	38.0
Average width (cm) at 56 days	605	11.9	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	296	70.9	36.9	1.0	100.0
Average number of days to first flower within 56 days	68	46.0	8.8	28.0	56.0
Percent of plants producing fruit	263	73.4	34.8	1.0	100.0
Average number of days from planting until first fruit formed on plant	234	95.6	25.9	36.0	150.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1148	40.4	16.6	1.0	186.0
Germination rate: percent of seeds germinated 14 days after planting	1113	65.9	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	1032	8.6	2.6	1.0	14.0
Number of plants measured	640	19.8	13.1	1.0	70.0
Average height (cm) at 56 days	656	20.3	9.6	8.0	38.0
Average width (cm) at 56 days	604	11.7	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	288	71.6	35.4	1.0	100.0
Average number of days to first flower within 56 days	58	45.5	9.2	28.0	56.0
Percent of plants producing fruit	256	74.9	33.7	1.0	100.0
Average number of days from planting until first fruit formed on plant	230	95.4	26.1	35.0	150.0

"More interesting than reading about it - more active and fun."

—Chicago, IL (elementary)

Questions 2-11: **Space-exposed Summary, Canister 4, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std.Dev.	Min.	Max.
Number of seeds planted	113	39.7	16.7	1.0	95.0
Germination rate: percent of seeds germinated 14 days after planting	111	63.8	20.9	6.0	98.0
Average number of days required for germination within 14 days after planting	106	8.3	2.5	2.0	14.0
Number of plants measured	56	17.4	13.4	1.0	56.0
Average height (cm) at 56 days	54	23.5	9.0	8.0	38.0
Average width (cm) at 56 days	52	13.0	3.8	4.0	16.0
Flowering rate: percent of plants producing flowers	36	75.9	37.2	1.0	100.0
Average number of days to first flower within 56 days	9	45.4	8.8	29.0	56.0
Percent of plants producing fruit	30	74.7	37.2	1.0	100.0
Average number of days from planting until first fruit formed on plant	30	86.1	32.2	36.0	150.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	113	39.4	16.6	1.0	95.0
Germination rate: percent of seeds germinated 14 days after planting	111	61.6	22.1	5.0	100.0
Average number of days required for germination within 14 days after planting	103	8.2	2.6	2.0	14.0
Number of plants measured	54	16.9	12.8	1.0	50.0
Average height (cm) at 56 days	54	22.4	9.2	8.0	38.0
Average width (cm) at 56 days	50	12.8	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	35	76.6	34.6	1.0	100.0
Average number of days to first flower within 56 days	10	42.2	9.5	30.0	55.0
Percent of plants producing fruit	27	83.1	31.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	28	88.0	30.1	40.0	150.0

> ***"As a scientist I am very concerned about the kind of exposure my son receives in his classrooms with regard to science. This project provided me the opportunity to enrich his curriculum as well as that of his fellow students. I found the experience to be a lot of fun and satisfying. I think there is something very exciting about participating in our country's space program that cannot be paralleled. It created an instant enthusiasm for the idea of a scientific experience. No one had to coax the children's interest."***
>
> —San Diego, CA (parent)

Questions 2-11: **Space-exposed Summary, Canister 4, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	956	40.2	15.8	4.0	150.0
Germination rate: percent of seeds germinated 14 days after planting	930	68.2	23.9	1.0	100.0
Average number of days required for germination within 14 days after planting	869	8.4	2.5	1.0	14.0
Number of plants measured	546	20.0	12.6	1.0	71.0
Average height (cm) at 56 days	557	20.8	9.8	8.0	38.0
Average width (cm) at 56 days	512	11.9	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	246	69.2	37.5	1.0	100.0
Average number of days to first flower within 56 days	54	46.0	8.9	28.0	56.0
Percent of plants producing fruit	218	71.9	35.1	1.0	100.0
Average number of days from planting until first fruit formed on plant	193	96.7	25.3	36.0	150.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	955	40.1	16.3	4.0	186.0
Germination rate: percent of seeds germinated 14 days after planting	923	66.2	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	854	8.6	2.6	1.0	14.0
Number of plants measured	541	19.7	12.6	1.0	70.0
Average height (cm) at 56 days	557	20.2	9.6	8.0	38.0
Average width (cm) at 56 days	513	11.7	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	240	70.1	35.9	1.0	100.0
Average number of days to first flower within 56 days	46	45.5	9.0	28.0	56.0
Percent of plants producing fruit	214	72.8	34.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	188	97.1	24.9	39.0	150.0

"Mahalo nui loa (Thank you very much.)"

—Kaneohe, HI. (elementary)

Questions 2-11: **Space-exposed Summary, Canister 4, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	25	46.2	21.4	10.0	118.0
Germination rate: percent of seeds germinated 14 days after planting	24	61.3	29.5	3.0	100.0
Average number of days required for germination within 14 days after planting	22	7.8	2.4	4.0	12.0
Number of plants measured	9	14.8	10.9	2.0	31.0
Average height (cm) at 56 days	11	15.7	6.5	8.0	28.0
Average width (cm) at 56 days	10	9.4	3.4	4.0	13.0
Flowering rate: percent of plants producing flowers	5	81.6	19.9	57.0	100.0
Average number of days to first flower within 56 days	2	47.5	10.6	40.0	55.0
Percent of plants producing fruit	4	85.5	20.3	57.0	100.0
Average number of days from planting until first fruit formed on plant	4	95.5	20.9	68.0	119.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	25	49.4	27.6	10.0	154.0
Germination rate: percent of seeds germinated 14 days after planting	23	62.3	25.9	8.0	96.0
Average number of days required for germination within 14 days after planting	21	7.7	2.9	2.0	13.0
Number of plants measured	11	17.2	14.9	1.0	40.0
Average height (cm) at 56 days	11	17.5	8.5	8.0	38.0
Average width (cm) at 56 days	10	9.1	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	3	82.0	15.7	71.0	100.0
Average number of days to first flower within 56 days	1	55.0	–	55.0	55.0
Percent of plants producing fruit	3	86.3	14.6	71.0	100.0
Average number of days from planting until first fruit formed on plant	3	96.3	27.1	68.0	122.0

"This project has been an excellent opportunity for our students and our community to be involved in true scientific research where no one knows the answers before the research is complete."

—Lacomb, Alberta, (secondar

Questions 2-11: **Space-exposed Summary, Canister 4, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	47	42.7	14.9	10.0	85.0
Germination rate: percent of seeds germinated 14 days after planting	46	66.8	28.2	2.0	100.0
Average number of days required for germination within 14 days after planting	44	8.3	2.6	3.0	14.0
Number of plants measured	28	24.9	16.2	5.0	53.0
Average height (cm) at 56 days	29	19.9	9.3	8.0	38.0
Average width (cm) at 56 days	24	12.0	4.7	4.0	16.0
Flowering rate: percent of plants producing flowers	11	93.6	12.1	60.0	100.0
Average number of days to first flower within 56 days	1	40.0	—	40.0	40.0
Percent of plants producing fruit	12	88.8	19.3	50.0	100.0
Average number of days from planting until first fruit formed on plant	10	100.9	19.1	60.0	121.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	47	43.8	15.4	10.0	85.0
Germination rate: percent of seeds germinated 14 days after planting	46	63.7	24.8	2.0	100.0
Average number of days required for germination within 14 days after planting	44	8.6	2.6	4.0	14.0
Number of plants measured	28	23.9	15.5	2.0	50.0
Average height (cm) at 56 days	29	18.9	9.8	8.0	38.0
Average width (cm) at 56 days	24	11.6	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	12	88.6	25.1	13.0	100.0
Average number of days to first flower within 56 days	1	30.0	—	30.0	30.0
Percent of plants producing fruit	13	82.2	26.2	13.0	100.0
Average number of days from planting until first fruit formed on plant	13	88.7	30.9	35.0	120.0

> *"The experience was a success for the students whose awareness of science in general and exposure to experimental procedure was definitely enhanced."*
>
> —Mertzon, TX (parent)

Questions 2-11: **Space-exposed Summary, Canister 5, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1090	40.9	15.4	2.0	184.0
Germination rate: percent of seeds germinated 14 days after planting	1067	64.1	24.5	1.0	100.0
Average number of days required for germination within 14 days after planting	996	8.5	2.6	1.0	14.0
Number of plants measured	621	18.9	12.9	1.0	77.0
Average height (cm) at 56 days	630	20.7	10.0	8.0	38.0
Average width (cm) at 56 days	583	11.9	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	288	71.9	35.4	1.0	100.0
Average number of days to first flower within 56 days	72	46.9	8.3	29.0	56.0
Percent of plants producing fruit	258	73.2	34.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	228	96.9	24.5	40.0	150.0

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1088	41.1	15.8	2.0	184.0
Germination rate: percent of seeds germinated 14 days after planting	1057	62.2	23.9	1.0	100.0
Average number of days required for germination within 14 days after planting	980	8.7	2.6	1.0	14.0
Number of plants measured	604	18.5	12.6	1.0	63.0
Average height (cm) at 56 days	626	20.6	9.8	8.0	38.0
Average width (cm) at 56 days	575	11.7	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	277	75.1	33.3	1.0	100.0
Average number of days to first flower within 56 days	72	48.1	7.7	30.0	56.0
Percent of plants producing fruit	243	75.7	32.8	1.0	100.0
Average number of days from planting until first fruit formed on plant	223	95.9	24.7	35.0	150.0

"... had trouble with the cool Vermont weather. I had fun, did a term paper on this experiment and received an A+, and most importantly, I learned a lot! But the next time I take on a similar project, I think I'll move down south."

—Shelburne, VT. (student)

Questions 2-11: **Space-exposed Summary, Canister 5, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	107	38.1	15.2	2.0	72.0
Germination rate: percent of seeds germinated 14 days after planting	102	59.0	24.9	1.0	100.0
Average number of days required for germination within 14 days after planting	97	8.6	2.8	3.0	14.0
Number of plants measured	61	15.8	11.7	1.0	46.0
Average height (cm) at 56 days	61	20.6	9.4	8.0	38.0
Average width (cm) at 56 days	53	12.[illegible]	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	37	70.1	35.9	1.0	100.0
Average number of days to first flower within 56 days	12	49.7	5.6	38.0	56.0
Percent of plants producing fruit	30	66.3	36.7	1.0	100.0
Average number of days from planting until first fruit formed on plant	26	92.8	26.6	50.0	150.0

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	107	37.9	16.3	2.0	85.0
Germination rate: percent of seeds germinated 14 days after planting	101	56.7	24.8	5.0	100.0
Average number of days required for germination within 14 days after planting	97	8.8	2.7	3.0	14.0
Number of plants measured	60	14.9	10.7	2.0	44.0
Average height (cm) at 56 days	61	19.6	9.0	8.0	38.0
Average width (cm) at 56 days	53	12.1	4.7	4.0	16.0
Flowering rate: percent of plants producing flowers	35	75.0	32.1	2.0	100.0
Average number of days to first flower within 56 days	12	50.5	5.4	37.0	56.0
Percent of plants producing fruit	26	72.1	33.6	1.0	100.0
Average number of days from planting until first fruit formed on plant	23	93.0	27.2	50.0	140.0

"The children learned a lot about controlling variables, observing, communicating, and awareness of the role of science in their daily lives."

—Portsmouth, OH, (elementary)

Questions 2-11: **Space-exposed Summary, Canister 5, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	918	41.1	15.2	2.0	184.0
Germination rate: percent of seeds germinated 14 days after planting	900	64.4	24.6	1.0	100.0
Average number of days required for germination within 14 days after planting	838	8.5	2.6	1.0	14.0
Number of plants measured	526	19.3	12.9	1.0	77.0
Average height (cm) at 56 days	534	20.7	10.1	8.0	38.0
Average width (cm) at 56 days	498	11.8	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	240	71.8	35.8	1.0	100.0
Average number of days to first flower within 56 days	55	46.6	8.5	29.0	56.0
Percent of plants producing fruit	214	73.6	34.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	190	98.2	23.9	40.0	150.0

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	916	41.1	15.6	3.0	184.0
Germination rate: percent of seeds germinated 14 days after planting	893	62.5	23.9	1.0	100.0
Average number of days required for germination within 14 days after planting	825	8.7	2.6	1.0	14.0
Number of plants measured	513	18.8	12.7	1.0	63.0
Average height (cm) at 56 days	532	20.7	9.8	8.0	38.0
Average width (cm) at 56 days	492	11.6	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	231	74.4	34.0	1.0	100.0
Average number of days to first flower within 56 days	56	47.8	8.2	30.0	56.0
Percent of plants producing fruit	203	75.4	33.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	188	97.1	24.3	35.0	150.0

"Thank you for giving America's schoolchildren an opportunity to really be a part of the space program. I am thrilled with the level of interest today's youth has for anything that has to do with space."

—Port Orchard, WA. (elementary)

Questions 2-11: **Space-exposed Summary, Canister 5, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	28	42.7	15.0	12.0	65.0
Germination rate: percent of seeds germinated 14 days after planting	25	70.2	24.6	2.0	100.0
Average number of days required for germination within 14 days after planting	24	6.8	2.5	2.0	11.0
Number of plants measured	14	17.5	13.3	1.0	44.0
Average height (cm) at 56 days	11	22.5	7.9	8.0	33.0
Average width (cm) at 56 days	12	12.8	4.9	4.0	16.0
Flowering rate: percent of plants producing flowers	6	90.0	24.5	40.0	100.0
Average number of days to first flower within 56 days	2	43.0	18.4	30.0	56.0
Percent of plants producing fruit	7	90.0	26.5	30.0	100.0
Average number of days from planting until first fruit formed on plant	6	83.5	23.0	45.0	109.0

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	28	42.8	14.9	12.0	65.0
Germination rate: percent of seeds germinated 14 days after planting	25	70.0	23.9	6.0	100.0
Average number of days required for germination within 14 days after planting	22	7.2	2.3	3.0	12.0
Number of plants measured	11	16.9	9.5	6.0	41.0
Average height (cm) at 56 days	10	21.0	7.5	8.0	33.0
Average width (cm) at 56 days	10	13.0	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	6	93.3	16.3	60.0	100.0
Average number of days to first flower within 56 days	2	50.5	7.8	45.0	56.0
Percent of plants producing fruit	7	91.4	22.7	40.0	100.0
Average number of days from planting until first fruit formed on plant	6	85.2	17.3	60.0	105.0

"In general, this has been extremely beneficial in every respect. The students developed an understanding of the needs and fragility of growing plants and their structure. The experiment was easily integrated in our language arts, math, and environmental study programs. Students developed social skills as they worked in groups, shared their discoveries, and compared their data with their peers."

—Glouchester, Ontario,
(elementary)

Questions 2-11: **Space-exposed Summary, Canister 5, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	42	40.2	15.9	9.0	64.0
Germination rate: percent of seeds germinated 14 days after planting	41	66.8	21.3	20.0	100.0
Average number of days required for germination within 14 days after planting	38	8.6	2.9	1.0	14.0
Number of plants measured	23	16.9	13.3	4.0	50.0
Average height (cm) at 56 days	25	22.4	11.1	8.0	38.0
Average width (cm) at 56 days	22	12.7	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	7	58.7	36.9	5.0	100.0
Average number of days to first flower within 56 days	4	41.3	9.7	30.0	52.0
Percent of plants producing fruit	7	74.9	31.7	22.0	100.0
Average number of days from planting until first fruit formed on plant	7	102.0	35.2	54.0	150.0

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	41	41.3	16.1	9.0	78.0
Germination rate: percent of seeds germinated 14 days after planting	40	63.4	21.8	23.0	100.0
Average number of days required for germination within 14 days after planting	37	8.7	2.8	3.0	14.0
Number of plants measured	22	16.4	13.9	2.0	50.0
Average height (cm) at 56 days	24	21.3	11.2	8.0	38.0
Average width (cm) at 56 days	20	13.6	3.7	4.0	16.0
Flowering rate: percent of plants producing flowers	7	65.6	40.3	5.0	100.0
Average number of days to first flower within 56 days	3	39.3	5.1	35.0	45.0
Percent of plants producing fruit	7	81.0	27.6	22.0	100.0
Average number of days from planting until first fruit formed on plant	6	94.3	34.8	53.0	150.0

> ***"Thanks for the opportunity to share in some REAL science — exciting stuff! . . . The students were* thrilled *to be involved in the project. It was good for them to do something that was so newsworthy!"***
>
> —Butner, NC, (secondary)

Questions 2-11: **Space-exposed Summary, Canister 7, Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	1085	40.8	19.9	3.0	325.0
Germination rate: percent of seeds germinated 14 days after planting	1054	67.2	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	980	8.5	2.5	1.0	14.0
Number of plants measured	599	19.6	12.9	1.0	66.0
Average height (cm) at 56 days	611	20.7	9.6	8.0	38.0
Average width (cm) at 56 days	563	12.1	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	292	74.9	33.9	1.0	100.0
Average number of days to first flower within 56 days	63	47.7	9.0	28.0	56.0
Percent of plants producing fruit	269	73.8	35.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	238	95.4	24.9	36.0	150.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	1083	40.7	18.2	2.0	339.0
Germination rate: percent of seeds germinated 14 days after planting	1048	64.9	23.4	1.0	100.0
Average number of days required for germination within 14 days after planting	968	8.8	2.5	1.0	14.0
Number of plants measured	584	18.9	12.6	1.0	63.0
Average height (cm) at 56 days	610	20.3	9.4	8.0	38.0
Average width (cm) at 56 days	558	12.1	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	289	74.8	33.8	1.0	100.0
Average number of days to first flower within 56 days	65	48.3	8.5	28.0	56.0
Percent of plants producing fruit	264	73.3	35.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	234	94.4	24.7	36.0	150.0

"The seed packet forwarded by NASA was placed with other items inside a time capsule which was buried on Earth Day 1990 on our high school campus. We plan to unearth the capsule in 20 years and germinate the seeds to ascertain the effects of time on the viability of the space-exposed seeds. In 20 years we will forward our results."

—Rochester, MN, (secondary)

Questions 2-11: **Space-exposed Summary, Canister 7, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	97	35.2	15.6	5.0	82.0
Germination rate: percent of seeds germinated 14 days after planting	88	65.9	23.3	2.0	100.0
Average number of days required for germination within 14 days after planting	85	8.4	2.5	3.0	14.0
Number of plants measured	50	16.9	11.7	2.0	51.0
Average height (cm) at 56 days	53	23.6	8.9	8.0	38.0
Average width (cm) at 56 days	51	13.2	3.5	4.0	16.0
Flowering rate: percent of plants producing flowers	41	74.4	35.7	1.0	100.0
Average number of days to first flower within 56 days	7	52.0	3.9	45.0	56.0
Percent of plants producing fruit	41	74.4	33.9	1.0	100.0
Average number of days from planting until first fruit formed on plant	35	91.2	21.7	56.0	142.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Using Your Own Soil Mixture For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	96	35.9	15.3	5.0	71.0
Germination rate: percent of seeds germinated 14 days after planting	91	62.4	25.3	1.0	100.0
Average number of days required for germination within 14 days after planting	87	8.8	2.5	3.0	14.0
Number of plants measured	49	16.8	11.5	2.0	53.0
Average height (cm) at 56 days	52	23.1	8.9	8.0	38.0
Average width (cm) at 56 days	49	13.7	3.3	4.0	16.0
Flowering rate: percent of plants producing flowers	40	79.2	30.6	2.0	100.0
Average number of days to first flower within 56 days	8	47.9	4.6	40.0	54.0
Percent of plants producing fruit	39	77.3	34.0	1.0	100.0
Average number of days from planting until first fruit formed on plant	34	89.6	22.6	52.0	144.0

"The project was indeed exciting for all of us, seeds from space! Do it again! Science is alive and well for my 6th graders. They felt a part of a 'real world' project. Thanks!"

—Robbinsdale, MN. (elementary)

Questions 2-11: Space-exposed Summary, Canister 7, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	926	41.5	20.5	5.0	325.0
Germination rate: percent of seeds germinated 14 days after planting	904	67.2	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	837	8.5	2.5	1.0	14.0
Number of plants measured	517	19.6	12.9	1.0	66.0
Average height (cm) at 56 days	523	20.3	9.6	8.0	38.0
Average width (cm) at 56 days	478	12.1	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	232	74.3	34.1	1.0	100.0
Average number of days to first flower within 56 days	53	47.1	9.5	28.0	56.0
Percent of plants producing fruit	213	73.3	35.4	1.0	100.0
Average number of days from planting until first fruit formed on plant	188	96.5	25.6	36.0	150.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Using Commercial Potting Soil For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	924	41.3	18.6	2.0	339.0
Germination rate: percent of seeds germinated 14 days after planting	896	65.0	23.3	1.0	100.0
Average number of days required for germination within 14 days after planting	824	8.8	2.6	1.0	14.0
Number of plants measured	504	18.9	12.7	1.0	63.0
Average height (cm) at 56 days	524	19.9	9.4	8.0	38.0
Average width (cm) at 56 days	476	11.9	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	233	73.5	34.7	1.0	100.0
Average number of days to first flower within 56 days	55	48.3	8.9	28.0	56.0
Percent of plants producing fruit	212	71.9	35.7	1.0	100.0
Average number of days from planting until first fruit formed on plant	187	95.6	25.0	36.0	150.0

"The enthusiasm generated was outstanding. Although only a few of my students actually worked at the project itself, the activity impacted almost all of our students from K to 12. The project was featured as a special report in our local newspaper and all ages of people expressed interest and curiosity in the progress of our experiment. A local senior citizens group nurtured a set of plants for us."

—Harrisburg, PA (secondary)

Questions 2-11: **Space-exposed Summary, Canister 7, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	17	32.6	16.8	9.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	17	74.6	21.7	20.0	100.0
Average number of days required for germination within 14 days after planting	17	8.0	2.3	4.0	11.0
Number of plants measured	6	18.7	16.2	6.0	47.0
Average height (cm) at 56 days	8	19.9	11.9	8.0	38.0
Average width (cm) at 56 days	8	12.6	4.1	7.0	16.0
Flowering rate: percent of plants producing flowers	3	66.0	54.6	3.0	100.0
Average number of days to first flower within 56 days	0	0	0	0	0
Percent of plants producing fruit	3	34.0	48.8	1.0	90.0
Average number of days from planting until first fruit formed on plant	3	111.0	41.2	66.0	147.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Using Paper Towel, Blotter, or Sponge For Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	17	32.3	16.5	8.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	16	68.1	17.7	48.0	100.0
Average number of days required for germination within 14 days after planting	16	8.7	2.3	5.0	12.0
Number of plants measured	6	18.0	17.8	4.0	50.0
Average height (cm) at 56 days	8	20.5	11.9	8.0	38.0
Average width (cm) at 56 days	8	11.9	4.5	7.0	16.0
Flowering rate: percent of plants producing flowers	2	96.5	4.9	93.0	100.0
Average number of days to first flower within 56 days	0	0	0	0	0
Percent of plants producing fruit	2	51.5	57.3	11.0	92.0
Average number of days from planting until first fruit formed on plant	2	106.5	55.9	67.0	146.0

"This has been an amazing cooperation between kids, parents, school, and government. It was beneficial because it made the children feel like they were a part of the space program itself."

—Schenectady, NY, (elementary)

Questions 2-11: **Space-exposed Summary, Canister 7, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	46	40.4	15.3	3.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	46	67.2	26.9	4.0	100.0
Average number of days required for germination within 14 days after planting	46	8.6	2.2	4.0	14.0
Number of plants measured	18	21.1	12.2	7.0	48.0
Average height (cm) at 56 days	21	21.3	10.0	8.0	38.0
Average width (cm) at 56 days	21	11.1	4.5	4.0	16.0
Flowering rate: percent of plants s producing flower	11	86.9	20.8	33.0	100.0
Average number of days to first flower within 56 days	1	56.0	—	56.0	56.0
Percent of plants producing fruit	10	84.2	31.1	22.0	100.0
Average number of days from planting until first fruit formed on plant	10	94.8	13.9	62.0	109.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Using Other Germination Media (Question 4), Grades 5-9**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	46	40.3	15.3	3.0	59.0
Germination rate: percent of seeds germinated 14 days after planting	44	67.7	26.1	10.0	100.0
Average number of days required for germination within 14 days after planting	42	9.9	2.8	5.0	14.0
Number of plants measured	18	18.0	9.3	6.0	41.0
Average height (cm) at 56 days	29	19.6	8.5	8.0	38.0
Average width (cm) at 56 days	30	10.3	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	10	81.7	21.6	33.0	100.0
Average number of days to first flower within 56 days	1	56.0	—	56.0	56.0
Percent of plants producing fruit	9	93.3	13.8	62.0	100.0
Average number of days from planting until first fruit formed on plant	9	95.3	14.2	62.0	113.0

> ***"I represent the children who are the original scientists. I only guide them. THEY do the hands-on learning. I only guide them. AND THAT'S WHAT IT'S ALL ABOUT BECAUSE THESE SPACE KIDS ARE #1!"***
>
> —Danville, IN, (elementary)

Question 15: **Growth Conditions of Plants After Four True Leaves Developed, Grades 5-9**

The table presents SEEDS data from question 15 of the Project Report which asked respondents to indicate as many growth conditions as applied to the experiment

Growth Conditions	Number reporting	Growth Conditions	Number reporting
Plants grown indoors	3903	Plants grown outdoors	1860
Grown in window facing South	958	Grown in window facing North	538
Grown in window facing West	717	Grown in window facing East	809
Grown in window facing Northeast	232	Grown in window facing Northwest	186
Grown in window facing Southeast	216	Grown in window facing Southwest	226
Grown under fluorescent light	1919	Grown under incandescent light	227
Grown under other types of light	188	Grown under Gro-lites	443
Grown inside- container 11 L (3 gal) or less	3601	Grown outside- container 11 L (3 gal) or less	858
Grown inside- container 15 L (4 gal)	87	Grown outside- container 15 L (4 gal)	71
Grown inside- container 19 L (5 gal)	76	Grown outside- container 19 L (5 gal)	112
Grown inside- container 23 L (6 gal)	51	Grown outside- container 23 L (6 gal)	38
Grown inside- container 27 L (7 gal) or more	69	Grown outside- container 27 L (7 gal) or more	77
Grown in garden plot	1398	Grown in full sun	1203
Grown in partial shade	1069	Grown in full shade	113
Grown in Greenhouse	333		

Questions 16-19: **School Classrooms Reporting SEEDS Data, Grades 5-9**

Information on this page concerns the school and classroom structure of SEEDS participants. The number of grades 5-9 students participating, question 20, is on page 140.

	School System Enrollment 26,000+	School System Enrollment 6,501-26,000	School System Enrollment 2,601-6,500	School System Enrollment 2,600 & Below
Number of public schools reporting	587	874	938	2495
Public schools as percent of total public and private	10.5	15.6	16.7	44.5
Number of private schools reporting	27	40	16	627
Private schools as percent of total public and private	0.5	0.7	0.3	11.2
Participated in agriculture class	16	4	7	34
Participated in mathematics class	20	21	15	53
Participated in science class	376	557	579	2054
Participated in other type of class	223	356	355	1007
Regular classroom structure	484	770	813	2738
LD, EMH, or EMR, ED	36	41	38	103
AP or G/T	58	74	69	147
Hearing impaired	1	2	0	13
Visually impaired	2	0	2	13
Other classroom structure	35	33	29	134

"It has been a tremendous experience for the students. Many have become much more interested in science."

—Asharon, Ontario, (elementary)

These two tables record the grade levels of the participating classes, the type of experiment performed, and future plans for experimenting. Nonschool investigators were probably some of the 205 reports with no response to question 21. It is also likely that some of the grades K-4 investigators may have omitted this item because they did not fit into any of the three available categories. The large number of grades 5-6 investigators does indicate that most grades K-4 participants, who revealed their presence in the many letters to NASA, selected this category when they completed the report form.

Question 21: **Level of Class, Grades 5-9**

Elementary	grades 5-6	4254
Middle	grades 6-8	1276
Junior high	grades 7-9	682

Questions 22-24: **Experimental Design, Continuation, and Termination, Grades 5-9**

	Number Reported	Percent of Total
Performed NASA-suggested experiments	5685	95.0
Performed student-designed experiments	302	5.0
Plans to continue experiments with subsequent generations of seeds	2688	44.5
Does not plan to continue experiments with subsequent generations of seeds	3357	55.5
Terminated the experiment when the required observations for the report were completed	2051	36.2
Terminated the experiment when the plants died or the experiment was interrupted	2188	38.6
Terminated the experiment for other reasons	1427	25.2

The next three pages display data correlating plant height 56 days after germination (question 7) with growing conditions (question 15). Only grades 5-9 data, using the four major compass directions for indoor data, and full sun and partial sun for outdoor data were analyzed in this fashion due to insufficient data for statistical treatment of the other compass directions and grade levels.

Mean Height in Centimeters for Plants Grown Indoors, in Windows Facing North, Under Fluorescent Lighting, in 11 liter (3 Gallon) Containers, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	19	12.7	6.6	8.0	28.0
Experimenters	Earth-based	18	13.6	5.9	8.0	23.0
Canister 3	Space-exposed	21	18.7	9.1	8.0	38.0
Experimenters	Earth-based	21	17.0	8.3	8.0	38.0
Canister 4	Space-exposed	16	23.9	9.5	8.0	38.0
Experimenters	Earth-based	16	23.6	10.6	8.0	38.0
Canister 5	Space-exposed	12	17.2	8.5	8.0	33.0
Experimenters	Earth-based	11	18.0	7.7	8.0	33.0
Canister 7	Space-exposed	14	19.4	9.7	8.0	38.0
Experimenters	Earth-based	14	20.5	9.1	8.0	38.0

Mean Height in Centimeters for Plants Grown Indoors, in Windows Facing South, Under Fluorescent Lighting, in 11 liter (3 Gallon) Containers, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	32	20.2	10.5	8.0	38.0
Experimenters	Earth-based	32	20.2	9.7	8.0	38.0
Canister 3	Space-exposed	33	20.4	10.3	8.0	38.0
Experimenters	Earth-based	33	21.5	11.1	8.0	38.0
Canister 4	Space-exposed	37	18.4	5.9	8.0	38.0
Experimenters	Earth-based	34	12.8	4.1	8.0	33.0
Canister 5	Space-exposed	30	18.3	7.6	8.0	38.0
Experimenters	Earth-based	31	17.8	7.8	8.0	33.0
Canister 7	Space-exposed	27	19.1	9.9	8.0	38.0
Experimenters	Earth-based	27	19.3	10.1	8.0	38.0

"All tomatoes had a very definite yellow star on the bottom and several had yellow flecks on their skin. The children knew they had been touched by the stars. We did creative writing about the fruit and the results were excellent."

—Rossville, TN (elementary)

Mean Height in Centimeters for Plants Grown Indoors, in Windows Facing East, Under Fluorescent Lighting, in 11 Liter (3 Gallon) Containers, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	23	18.9	10.1	8.0	38.0
Experimenters	Earth-based	23	19.1	10.3	8.0	38.0
Canister 3	Space-exposed	38	19.3	8.8	8.0	38.0
Experimenters	Earth-based	38	19.6	9.5	8.0	38.0
Canister 4	Space-exposed	34	20.9	10.6	8.0	38.0
Experimenters	Earth-based	33	20.1	10.0	8.0	38.0
Canister 5	Space-exposed	26	18.2	9.8	8.0	38.0
Experimenters	Earth-based	26	19.7	9.6	8.0	38.0
Canister 7	Space-exposed	30	19.2	9.2	8.0	38.0
Experimenters	Earth-based	30	19.5	9.1	8.0	38.0

Mean Height in Centimeters for Plants Grown Indoors, in Windows Facing West, Under Fluorescent Lighting, in 11 Liter (3 Gallon) Containers, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	27	17.6	7.2	8.0	33.0
Experimenters	Earth-based	27	16.9	8.5	8.0	38.0
Canister 3	Space-exposed	26	21.1	11.1	8.0	38.0
Experimenters	Earth-based	26	20.1	11.8	8.0	38.0
Canister	Space-exposed	40	22.3	8.7	8.0	38.0
4 Experimenters	Earth-based	40	21.8	8.6	8.0	38.0
Canister	Space-exposed	23	21.7	10.4	8.0	38.0
5 Experimenters	Earth-based	23	22.1	10.4	8.0	38.0
Canister 7	Space-exposed	30	16.8	16.8	8.0	38.0
Experimenters	Earth-based	30	16.3	16.3	8.0	38.0

Mean Height in Centimeters for Plants Grown Outdoors, in Garden Plots, in Partial Shade, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	35	21.6	10.0	8.0	38.0
Experimenters	Earth-based	35	21.7	9.6	8.0	38.0
Canister 3	Space-exposed	32	21.9	9.6	8.0	38.0
Experimenters	Earth-based	32	20.2	9.1	8.0	38.0
Canister 4	Space-exposed	31	16.2	8.2	8.0	33.0
Experimenters	Earth-based	33	16.6	9.0	8.0	33.0
Canister 5	Space-exposed	35	21.6	9.7	8.0	38.0
Experimenters	Earth-based	35	20.4	9.1	8.0	38.0
Canister 7	Space-exposed	39	18.3	9.5	8.0	38.0
Experimenters	Earth-based	39	18.5	9.3	8.0	38.0

Mean Height in Centimeters for Plants Grown Outdoors, in Garden Plots, in Full Sunlight, Grades 5-9

		Number reporting	Mean	Std. Dev.	Min.	Max.
Canister 2	Space-exposed	49	22.5	10.6	8.0	38.0
Experimenters	Earth-based	49	21.9	10.7	8.0	38.0
Canister 3	Space-exposed	53	22.5	9.7	8.0	38.0
Experimenters	Earth-based	53	21.5	9.2	8.0	38.0
Canister 4	Space-exposed	53	21.6	10.0	8.0	38.0
Experimenters	Earth-based	52	20.9	10.4	8.0	38.0
Canister 5	Space-exposed	56	23.9	10.7	8.0	38.0
Experimenters	Earth-based	56	22.8	10.2	8.0	38.0
Canister 7	Space-exposed	40	24.3	24.3	8.0	38.0
Experimenters	Earth-based	40	23.9	23.9	8.0	38.0

"It is exciting! Thank you for 'opening the minds' of America's children to science."

—Danville, IN. (elementary)

Data, Grades 10-12

The high school data report begins with a summary of the space-exposed seeds means across all layers and canisters.

Questions 5-11: **Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	1494	67.4	20.7	1.0	100.0
Average number of days required for germination within 14 days after planting	1335	8.1	2.6	1.0	14.0
Number of plants measured	816	14.9	10.7	1.0	88.0
Average height (cm) at 56 days	843	21.6	9.6	8.0	38.0
Average width (cm) at 56 days	798	12.3	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	342	79.3	30.5	1.0	100.0
Average number of days to first flower within 56 days	126	47.3	7.3	29.0	56.0
Percent of plants producing fruit	298	81.1	28.8	1.0	100.0
Average number of days from planting until first fruit formed on plant	260	91.5	25.1	36.0	150.0

The order of presentation of the data from grades 10-12 approximates the order of presentation in the preceding section. The data is presented for each canister as a set of three tables: one for layers AB, another for layers CD, and a third for the Earth-based control seeds grown by the experimenters for each canister.

Questions 5-11: **Earth-based Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	1481	66.1	22.4	1.0	100.0
Average number of days required for germination within 14 days after planting	1328	8.3	2.7	1.0	14.0
Number of plants measured	795	19.2	14.8	1.0	99.0
Average height (cm) at 56 days	837	21.5	9.7	8.0	38.0
Average width (cm) at 56 days	777	12.5	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	328	80.2	30.1	1.0	100.0
Average number of days to first flower within 56 days	125	47.6	7.9	28.0	56.0
Percent of plants producing fruit	287	82.6	27.6	1.0	100.0
Average number of days from planting until first fruit formed on plant	244	92.2	26.2	35.0	150.0

> ***"I believe the students learned quite a bit about what makes for good research and what factors compound the interpretation of possible results."***
>
> —Arlington, MA (elementary)

Questions 3: **Canister Identified on Seeds Package, Grades 10-12**

Canister, Layers	Number reporting
Canister 2, layers AB	340
Canister 2, layers CD	306
Canister 3, layers AB	267
Canister 3, layers CD	259
Canister 4, layers AB	247
Canister 4, layers CD	244
Canister 5, layers AB	202
Canister 5, layers CD	204
Canister 7, layers AB	289
Canister 7, layers CD	291

Questions 4: **Germination Media Used, Grades 10-12**

	Number reporting	Percentage
Own soil mixture	243	16.3
Commercial potting soil	1123	75.4
Moist paper towel/ blotter/ sponge	68	4.6
Other	56	3.8

Questions 2-11: **Canister 2, Layers AB, Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	315	28.5	18.6	1.0	150.0
Germination rate: percent of seeds germinated 14 days after planting	313	64.1	23.2	1.0	100.0
Average number of days required for germination within 14 days after planting	282	7.9	2.8	1.0	14.0
Number of plants measured	163	14.2	11.1	1.0	85.0
Average height (cm) at 56 days	183	21.2	9.7	8.0	38.0
Average width (cm) at 56 days	176	12.1	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	55	76.2	33.7	1.0	100.0
Average number of days to first flower within 56 days	16	42.9	8.7	30.0	56.0
Percent of plants producing fruit	45	79.6	29.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	38	98.4	26.4	43.0	150.0

> ***"Thank you for allowing us to participate in this excellent project. Right from the beginning there was great interest among my students, the rest of the school, and the community."***
>
> —Brucefield, Ontario, (elementary)

Questions 2-11: **Canister 2, Layers CD, Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	297	29.0	18.2	1.0	150.0
Germination rate: percent of seeds germinated 14 days after planting	297	64.8	23.5	1.0	100.0
Average number of days required for germination within 14 days after planting	266	7.8	2.7	1.0	14.0
Number of plants measured	158	13.6	9.9	1.0	59.0
Average height (cm) at 56 days	170	20.7	9.9	8.0	38.0
Average width (cm) at 56 days	160	12.3	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	55	79.2	31.5	1.0	100.0
Average number of days to first flower within 56 days	17	42.5	9.3	28.0	54.0
Percent of plants producing fruit	44	84.0	24.8	7.0	100.0
Average number of days from planting until first fruit formed on plant	38	98.4	25.4	43.0	146.0

Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	328	38.3	25.2	1.0	168.0
Germination rate: percent of seeds germinated 14 days after planting	324	63.3	24.6	2.0	100.0
Average number of days required for germination within 14 days after planting	299	8.2	2.9	1.0	14.0
Number of plants measured	167	16.9	13.3	1.0	67.0
Average height (cm) at 56 days	190	21.3	9.6	8.0	38.0
Average width (cm) at 56 days	176	12.4	4.3	4.0	16.0
Flowering rate: percent of plants producing flowers	56	79.6	31.4	1.0	100.0
Average number of days to first flower within 56 days	15	42.5	8.6	29.0	54.0
Percent of plants producing fruit	46	83.8	23.7	15.0	100.0
Average number of days from planting until first fruit formed on plant	39	98.9	27.5	40.0	150.0

"Our project was cut short when the leaves of our growing plants became dinner for our resident mice or other critters over the July 4th holiday. The project was an excellent exercise for our children. Their background in this area is weak and because of this project we were able to develop some of the necessary techniques in a scientific approach."

—Chicago, IL (elementary)

Questions 2-11: **Canister 3, Layers AB, Space-exposed Summary, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	248	31.8	24.3	2.0	247.0
Germination rate: percent of seeds germinated 14 days after planting	236	71.8	19.5	8.0	100.0
Average number of days required for germination within 14 days after planting	225	7.9	2.5	1.0	14.0
Number of plants measured	133	17.5	12.7	2.0	60.0
Average height (cm) at 56 days	145	22.8	10.2	8.0	38.0
Average width (cm) at 56 days	131	12.6	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	50	79.6	30.3	4.0	100.0
Average number of days to first flower within 56 days	18	48.6	5.6	36.0	56.0
Percent of plants producing fruit	39	79.5	29.9	2.0	100.0
Average number of days from planting until first fruit formed on plant	35	92.7	21.6	50.0	134.0

Questions 2-11: **Canister 3, Layers CD, Space-exposed Summary, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	246	32.6	26.1	2.0	252.0
Germination rate: percent of seeds germinated 14 days after planting	234	72.5	19.1	4.0	100.0
Average number of days required for germination within 14 days after planting	223	7.9	2.5	1.0	14.0
Number of plants measured	135	17.7	13.5	2.0	74.0
Average height (cm) at 56 days	147	22.6	10.2	8.0	38.0
Average width (cm) at 56 days	132	12.9	4.0	4.0	16.0
Flowering rate: percent of plants producing flowers	45	80.4	29.1	3.0	100.0
Average number of days to first flower within 56 days	12	47.2	5.8	35.0	56.0
Percent of plants producing fruit	32	81.6	28.4	2.0	100.0
Average number of days from planting until first fruit formed on plant	29	94.9	23.0	56.0	134.0

"It was and is a great learning experience. Our experiment is still going on!"

—Tucson, AZ, (elementary)

Questions 2-11: **Earth-based Summary, Canister 3 Experimenters, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	255	44.9	36.5	2.0	400.0
Germination rate: percent of seeds germinated 14 days after planting	246	68.8	21.0	8.0	100.0
Average number of days required for germination within 14 days after planting	235	8.1	2.5	2.0	14.0
Number of plants measured	137	21.1	16.3	1.0	99.0
Average height (cm) at 56 days	151	22.2	9.9	8.0	38.0
Average width (cm) at 56 days	137	13.0	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	50	78.1	30.2	2.0	100.0
Average number of days to first flower within 56 days	20	48.9	6.6	30.0	56.0
Percent of plants producing fruit	37	79.8	28.8	2.0	100.0
Average number of days from planting until first fruit formed on plant	34	93.5	22.7	56.0	134.0

Questions 2-11: **Canister 4, Layers AB, Space-exposed Summary, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	235	29.5	17.8	3.0	163.0
Germination rate: percent of seeds germinated 14 days after planting	236	69.5	20.6	3.0	100.0
Average number of days required for germination within 14 days after planting	215	8.3	2.6	2.0	14.0
Number of plants measured	117	13.9	7.9	1.0	35.0
Average height (cm) at 56 days	116	23.0	9.9	8.0	38.0
Average width (cm) at 56 days	115	12.9	4.1	4.0	16.0
Flowering rate: percent of plants producing flowers	66	86.0	23.9	8.0	100.0
Average number of days to first flower within 56 days	23	48.3	6.2	35.0	56.0
Percent of plants producing fruit	66	81.6	29.3	8.0	100.0
Average number of days from planting until first fruit formed on plant	57	84.9	25.7	45.0	150.0

> ***"This was a wonderful experience for them and generated much curiosity and enthusiasm in all who participated. I am sure it is something from their school days that they will be telling their children in the future."***
>
> —Fairfax, VA. (elementary)

Questions 2-11: **Canister 4, Layers CD, Space-exposed Summary, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	223	28.3	14.9	3.0	141.0
Germination rate: percent of seeds germinated 14 days after planting	224	68.1	20.1	16.0	100.0
Average number of days required for germination within 14 days after planting	205	8.2	2.6	2.0	14.0
Number of plants measured	119	12.8	8.2	1.0	45.0
Average height (cm) at 56 days	114	22.9	9.8	8.0	38.0
Average width (cm) at 56 days	114	12.8	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	66	84.0	26.0	8.0	100.0
Average number of days to first flower within 56 days	24	48.2	6.9	31.0	56.0
Percent of plants producing fruit	65	84.6	25.4	8.0	100.0
Average number of days from planting until first fruit formed on plant	57	86.5	25.3	48.0	150.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	247	40.4	27.2	3.0	256.0
Germination rate: percent of seeds germinated 14 days after planting	246	68.2	21.2	10.0	100.0
Average number of days required for germination within 14 days after planting	226	8.2	2.6	2.0	14.0
Number of plants measured	127	16.9	11.9	1.0	56.0
Average height (cm) at 56 days	124	23.8	10.0	8.0	38.0
Average width (cm) at 56 days	122	13.4	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	69	84.4	26.9	8.0	100.0
Average number of days to first flower within 56 days	28	49.1	5.5	39.0	56.0
Percent of plants producing fruit	69	83.6	29.3	5.0	100.0
Average number of days from planting until first fruit formed on plant	59	85.7	26.2	44.0	145.0

"The students did see that the government and news media thought that science and space were important. They also saw that as young Americans, they can be involved in space and science."

—Lansing, MI (secondary)

Questions 2-11: **Canister 5, Layers AB, Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	198	28.9	14.6	3.0	152.0
Germination rate: percent of seeds germinated 14 days after planting	195	65.9	21.8	3.0	100.0
Average number of days required for germination within 14 days after planting	165	8.1	2.7	1.0	14.0
Number of plants measured	112	13.5	8.4	1.0	32.0
Average height (cm) at 56 days	117	23.3	9.8	8.0	38.0
Average width (cm) at 56 days	109	12.6	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	38	80.5	32.4	1.0	100.0
Average number of days to first flower within 56 days	15	46.4	8.1	32.0	56.0
Percent of plants producing fruit	36	81.5	31.3	1.0	100.0
Average number of days from planting until first fruit formed on plant	32	90.2	18.7	55.0	142.0

Questions 2-11: **Canister 5, Layers CD, Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	188	29.3	13.5	2.0	90.0
Germination rate: percent of seeds germinated 14 days after planting	186	66.5	22.5	3.0	100.0
Average number of days required for germination within 14 days after planting	157	8.1	2.8	1.0	14.0
Number of plants measured	106	13.3	8.1	1.0	35.0
Average height (cm) at 56 days	113	23.0	10.1	8.0	38.0
Average width (cm) at 56 days	102	12.4	4.1	4.0	16.0
Flowering rate: percent of plants producing flowers	36	81.1	32.3	1.0	100.0
Average number of days to first flower within 56 days	13	48.6	7.3	35.0	56.0
Percent of plants producing fruit	34	85.3	28.2	6.0	100.0
Average number of days from planting until first fruit formed on plant	31	93.5	17.5	58.0	136.0

> ***"Thanks for the opportunity to participate in this exciting research. My students and I really enjoyed the experiment and the resulting tomato sandwiches!"***
>
> —Oak Ridge, TN. (secondary)

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	202	42.7	22.7	4.0	152.0
Germination rate: percent of seeds germinated 14 days after planting	199	64.4	21.4	3.0	100.0
Average number of days required for germination within 14 days after planting	167	8.4	2.9	2.0	14.0
Number of plants measured	114	18.9	13.4	1.0	61.0
Average height (cm) at 56 days	119	22.4	10.1	8.0	38.0
Average width (cm) at 56 days	109	12.3	4.2	4.0	16.0
Flowering rate: percent of plants producing flowers	39	79.7	32.7	1.0	100.0
Average number of days to first flower within 56 days	16	47.9	8.7	30.0	56.0
Percent of plants producing fruit	38	81.4	31.2	1.0	100.0
Average number of days from planting until first fruit formed on plant	31	88.8	16.2	59.0	115.0

Questions 2-11: **Canister 7, Layers AB, Space-exposed Summary, Grades 10-12**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	275	29.8	17.5	1.0	208.0
Germination rate: percent of seeds germinated 14 days after planting	276	66.4	22.6	3.0	100.0
Average number of days required for germination within 14 days after planting	250	8.5	2.6	2.0	14.0
Number of plants measured	162	15.6	10.2	1.0	59.0
Average height (cm) at 56 days	163	18.7	8.5	8.0	38.0
Average width (cm) at 56 days	151	11.8	4.4	4.0	16.0
Flowering rate: percent of plants producing flowers	64	82.2	26.7	2.0	100.0
Average number of days to first flower within 56 days	26	47.6	6.9	30.0	56.0
Percent of plants producing fruit	61	83.9	24.7	14.0	100.0
Average number of days from planting until first fruit formed on plant	53	90.1	26.7	37.0	145.0

"Wonderful learning experience. Some found it 'boring' when they had to perform the needed measuring and calculations, but that too was a lesson in itself."

—Winslow, ME. (secondary)

Questions 2-11: **Canister 7, Layers CD, Space-exposed Summary, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	278	28.6	13.5	1.0	118.0
Germination rate: percent of seeds germinated 14 days after planting	278	66.9	21.3	3.0	100.0
Average number of days required for germination within 14 days after planting	257	8.4	2.4	3.0	14.0
Number of plants measured	167	16.0	10.5	1.0	57.0
Average height (cm)	165	18.9	8.8	8.0	38.0
Average width (cm)	151	11.7	4.5	4.0	16.0
Flowering rate: percent of plants producing flowers	67	80.4	28.9	1.0	100.0
Average number of days to first flower	29	48.8	6.7	29.0	56.0
Percent of plants producing fruit	58	85.9	23.1	7.0	100.0
Average number of days from planting until first fruit formed on plant	49	89.7	27.0	35.0	147.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, Grades 10-12**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	291	39.8	21.6	1.0	212.0
Germination rate: percent of seeds germinated 14 days after planting	295	66.3	21.4	7.0	100.0
Average number of days required for germination within 14 days after planting	265	8.6	2.5	1.0	14.0
Number of plants measured	171	20.3	14.9	1.0	99.0
Average height (cm) at 56 days	168	19.1	9.1	8.0	38.0
Average width (cm) at 56 days	155	11.8	4.6	4.0	16.0
Flowering rate: percent of plants producing flowers	67	84.1	25.1	4.0	100.0
Average number of days to first flower within 56 days	30	48.8	8.1	29.0	56.0
Percent of plants producing fruit	61	84.9	23.6	1.0	100.0
Average number of days from planting until first fruit formed on plant	51	91.4	27.7	36.0	144.0

"I feel most privileged to witness firsthand such an experiment. I'm also saddened that all who had an opportunity did not take advantage to do so."

—Arcadia, CA (secondary)

Questions 15: **Growth Conditions of Plants After Four True Leaves Developed, Grades 10-12**

The table reports the type of environment in which the tomato plants were grown after they developed four true leaves. Correlations relating plant growth to germination media used or plant growth to environmental conditions were not presented because of insufficient data for validity in most of the categories. Tables correlating the growing environment with plant growth begin on page 83 utilizing the abundant grades 5-9 data.

Growth Conditions	Number reporting	Growth Conditions	Number reporting
Plants grown indoors	864	Plants grown outdoors	386
Grown in window facing South	222	Grown in window facing North	91
Grown in window facing West	145	Grown in window facing East	138
Grown in window facing Northeast	35	Grown in window facing Northwest	25
Grown in window facing Southeast	52	Grown in window facing Southwest	47
Grown under fluorescent light	322	Grown under incandescent light	65
Grown under other types of light	48	Grown under Gro-lites	174
Grown inside- container 11 L (3 gal) or less	831	Grown outside- container 11 L (3 gal) or less	155
Grown inside- container 15 L (4 gal)	13	Grown outside- container 15 L (4 gal)	11
Grown inside- container 19 L (5 gal)	16	Grown outside- container 19 L (5 gal)	13
Grown inside- container 23 L (6 gal)	2	Grown outside- container 23 L (6 gal)	3
Grown inside- container 27 L (7 gal) or more	12	Grown outside- container 27 L (7 gal) or more	13
Grown in garden plot	314	Grown in full sun	276
Grown in partial shade	189	Grown in full shade	15
Grown in greenhouse	255		

Questions 20-23: **Were Biochemical Tests Conducted? Grades 10-12**

Reported on this page are the number of researchers who performed biochemical tests on seeds or plants. The results of the tests, along with chromosome and microbial tests (questions 16-19), were reported separately and are briefly described in the narrative section of *SEEDS: A Celebration of Science*. Most investigators did not describe the outcomes of these tests.

	layers AB		layers CD		Earth- based	
	yes	**no**	**yes**	**no**	**yes**	**no**
Was a chromatographic test conducted on the plants?	15	9	15	6	16	7
Was a chromatographic test conducted on the seeds?	0	13	0	12	1	14
Was a spectrophotometric test conducted on the plants?	13	9	14	7	13	7
Was a spectrophotometric test conducted on the seeds?	0	12	0	11	1	11
Was an auxin identification analysis conducted on the plants?	2	12	3	10	2	12
Was an auxin identification analysis conducted on the seeds?	0	13	1	10	1	11
Was an electrophoresis analysis conducted on the plants?	5	12	3	12	5	12
Was an electrophoresis analysis conducted on the seeds?	0	13	0	12	0	13

"It made teaching of the scientific method and measurement and documentation much more meaningful. For many it was their first experience with growing plants."

—Spartanburg, SC. (secondary)

Questions 24-27: **School Classrooms Reporting SEEDS Data, Grades 10-12**

The table shows information about the schools and classes that reported data to SEEDS. Science classes were, by far, the more frequent users of SEEDS materials. It is interesting to note, however, that in letters from teachers, many across-the-curriculum uses were found for SEEDS. Students found themselves working with SEEDS data in math classes, writing about SEEDS and space travel in English, and discussing the space program and the history of space exploration in their social studies classes.

	School System Enrollment 26,001+	**School System Enrollment 6,501-26,000**	**School System Enrollment 2,601-6,500**	**School System Enrollment 2,600 & Below**
Number of public schools reporting	138	216	231	695
Public schools as percent of total public and private	9.7	15.2	16.2	48.9
Number of private schools reporting	4	1	1	135
Private schools as percent of total public and private	.3	.1	.1	9.5
Participated in agriculture class	4	1	8	32
Participated in mathematics class	1	3	4	5
Participated in science class	127	200	208	737
Participated in other type of class	10	13	12	63
Regular classroom structure	118	182	208	744
LD, EMH, or EMR, ED	8	16	12	24
Hearing impaired	2	0	0	5
Visually impaired	2	0	0	1
Other classroom structure	19	20	15	52

Questions 28, 30, 31: **Experimental Design, Continuation, and Termination, Grades 10-12**

Information regarding question 29 and the number of participating high school students is on page 110

	Number Reported	**Percent of Total**
Performed NASA-suggested experiments	1331	93.8
Performed student-designed experiments	87	6.2
Plans to continue experiments with subsequent generations of seeds	779	54.5
Does not plan to continue experiments with subsequent generations of seeds	650	45.5
Terminated the experiment when the required observations for the report were completed	455	36.6
Terminated the experiment when the plants died or the experiment was interrupted	480	38.6
Terminated the experiment for other reasons	307	24.7

"Students had the opportunity to practice the experimental method and to share with each other in many discussion periods. I have waited six years to be a part of the SEEDS Project. I was pleased with my students' positive attitudes towards it. Every day, many were directly involved in the experiments or made some comment to me about the seeds and plants. Students shared their parents' comments as well."

—Orchard Park, NY. (secondary)

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Data, College

College data begin on this page with a summary table of data from all canisters and all seed layers

Questions 5-11: **Space-exposed Summary Data, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	280	71.1	19.8	2.0	100.0
Average number of days required for germination within 14 days after planting	236	8.1	2.4	2.3	14.0
Number of plants measured	145	12.1	8.6	1.0	70.8
Average height (cm)	152	25.0	9.7	8.0	38.0
Average width (cm)	137	14.1	3.2	4.0	16.0
Flowering rate: percent of plants producing flowers	50	63.7	36.2	1.0	100.0
Average number of days to first flower	16	46.9	8.2	30.0	56.0
Percent of plants producing fruit	79	82.6	27.6	5.3	100.0
Average number of days from planting until first fruit formed on plant	66	89.9	24.6	38.5	150.0

Questions 5-11: **Earth-based Summary Data, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Germination rate: percent of seeds germinated 14 days after planting	269	69.8	21.5	4.0	100.0
Average number of days required for germination within 14 days after planting	222	8.1	2.5	2.0	14.0
Number of plants measured	141	18.1	16.8	1.0	96.0
Average height (cm)	148	25.0	9.9	8.0	38.0
Average width (cm)	132	14.1	3.3	4.0	16.0
Flowering rate: percent of plants producing flowers	42	69.5	34.1	2.0	100.0
Average number of days to first flower	14	47.2	6.9	34.0	56.0
Percent of plants producing fruit	70	87.2	23.9	10.0	100.0
Average number of days from planting until first fruit formed on plant	58	89.6	22.6	40.0	137.0

In keeping with the pattern established in the previous data sections, college data tables are presented in an order that approximates that of the SEEDS Report Form. After the space-exposed and Earth-based data summaries, data from questions 3 and 4 of the report form are displayed on page 110.

Subsequent pages display data for each layer grouped by canister as well as data from the Earth-based seeds grown by each canister's experimenters.

"With this experiment my children could extend their writing and measuring skills and develop a greater knowledge of plants and their growth patterns."

—East Providence, RI.
(elementary)

Question 3: **Canister Identified on Seeds Package, College**

Canister, layer	Number reporting
Canister 2, layer A	64
Canister 2, layer B	61
Canister 2, layer C	63
Canister 2, layer D	61
Canister 3, layer A	59
Canister 3, layer B	63
Canister 3, layer C	62
Canister 3, layer D	61
Canister 4, layer A	38
Canister 4, layer B	37
Canister 4, layer C	36
Canister 4, layer D	39
Canister 5, layer A	36
Canister 5, layer B	33
Canister 5, layer C	35
Canister 5, layer D	36
Canister 7, layer A	66
Canister 7, layer B	64
Canister 7, layer C	66
Canister 7, layer D	68

Question 4: **Germination Media Used, College**

	Number reporting	Percentage
Own soil mixture	50	17.2
Commercial potting soil	196	67.6
Moist paper towel/ blotter/ sponge	15	5.2
Other	29	10.0

Questions 2-11: **Canister 2, Layer A, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	56	23.5	12.9	3.0	80.0
Germination rate: percent of seeds germinated 14 days after planting	55	72.2	19.6	24.0	100.0
Average number of days required for germination within 14 days after planting	47	7.9	2.2	5.0	14.0
Number of plants measured	28	12.7	9.2	2.0	40.0
Average height (cm)	32	22.8	10.1	8.0	38.0
Average width (cm)	29	13.5	3.6	4.0	16.0
Flowering rate: percent of plants producing flowers	6	46.3	38.8	4.0	100.0
Average number of days to first flower	2	56.0	0	56.0	56.0
Percent of plants producing fruit	16	86.1	24.7	27.0	100.0
Average number of days from planting until first fruit formed on plant	15	91.3	20.3	56.0	124.0

"My students were able to benefit a great deal from this project. They discovered how the scientific method could be applicable to their lives."

—Anniston, AL (elementary)

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Questions 2-11: **Canister 2, Layer B, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	56	23.1	13.9	3.0	80.0
Germination rate: percent of seeds germinated 14 days after planting	57	70.6	20.7	13.0	100.0
Average number of days required for germination within 14 days after planting	50	7.9	2.3	4.0	14.0
Number of plants measured	28	12.9	9.4	2.0	32.0
Average height (cm)	31	21.2	9.4	8.0	38.0
Average width (cm)	29	13.1	3.4	4.0	16.0
Flowering rate: percent of plants producing flowers	5	44.2	32.7	15.0	100.0
Average number of days to first flower	1	56.0	—	56.0	56.0
Percent of plants producing fruit	18	84.2	27.8	4.0	100.0
Average number of days from planting until first fruit formed on plant	16	91.9	21.9	58.0	126.0

Questions 2-11: **Canister 2, Layer C, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	58	22.8	11.8	3.0	80.0
Germination rate: percent of seeds germinated 14 days after planting	56	75.1	19.3	5.0	100.0
Average number of days required for germination within 14 days after planting	50	7.9	2.3	4.0	14.0
Number of plants measured	30	13.3	8.4	2.0	39.0
Average height (cm)	33	23.2	9.3	8.0	38.0
Average width (cm)	28	13.8	3.8	4.0	16.0
Flowering rate: percent of plants producing flowers	5	68.0	25.6	42.0	100.0
Average number of days to first flower	1	56.0	—	56.0	56.0
Percent of plants producing fruit	17	82.4	31.2	4.0	100.0
Average number of days from planting until first fruit formed on plant	16	92.2	19.6	60.0	125.0

> ***"For many of the 5th graders this was their first experience with growing, measuring, and keeping records on a plant. This was my first experience with a project like this too. I believe I can do a better job if I ever get the opportunity to do this again."***
>
> —Batesville, MS. (elementary)

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Questions 2-11: **Canister 2, Layer D, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	56	21.2	12.2	2.0	80.0
Germination rate: percent of seeds germinated 14 days after planting	55	71.9	21.2	24.0	100.0
Average number of days required for germination within 14 days after planting	48	8.1	2.4	4.0	14.0
Number of plants measured	26	12.5	8.2	2.0	35.0
Average height (cm) at 56 days	30	22.7	9.2	8.0	38.0
Average width (cm) at 56 days	26	13.3	3.4	4.0	16.0
Flowering rate: percent of plants producing flowers	4	70.0	25.8	40.0	100.0
Average number of days to first flower within 56 days	0	—	—	—	—
Percent of plants producing fruit	16	86.4	26.6	8.0	100.0
Average number of days from planting until first fruit formed on plant	14	92.5	22.3	59.0	123.0

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Questions 2-11: **Earth-based Summary, Canister 2 Experimenters, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	63	35.0	35.0	3.0	241.0
Germination rate: percent of seeds germinated 14 days after planting	62	67.9	21.4	5.0	100.0
Average number of days required for germination within 14 days after planting	54	8.3	2.5	4.0	14.0
Number of plants measured	33	18.3	16.2	1.0	81.0
Average height (cm) at 56 days	35	23.4	9.9	8.0	38.0
Average width (cm) at 56 days	32	13.5	3.2	4.0	16.0
Flowering rate: percent of plants producing flowers	5	65.6	28.4	33.0	100.0
Average number of days to first flower within 56 days	1	56.0	—	56.0	56.0
Percent of plants producing fruit	16	88.4	22.4	28.0	100.0
Average number of days from planting until first fruit formed on plant	15	91.9	20.7	57.0	126.0

"I believe the students learned quite a bit about what makes for good research and what factors compound the interpretation of possible results."

—Arlington, MA (elementary)

Questions 2-11: **Canister 3, Layer A, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	60	16.8	11.0	3.0	75.0
Germination rate: percent of seeds germinated 14 days after planting	56	74.9	19.6	25.0	100.0
Average number of days required for germination within 14 days after planting	44	7.8	2.6	3.0	12.0
Number of plants measured	35	8.3	5.1	1.0	23.0
Average height (cm) at 56 days	39	24.5	10.4	8.0	38.0
Average width (cm) at 56 days	32	14.1	3.6	4.0	16.0
Flowering rate: percent of plants producing flowers	8	77.1	28.6	25.0	100.0
Average number of days to first flower within 56 days	2	48.0	11.3	40.0	56.0
Percent of plants producing fruit	17	91.1	21.2	24.0	100.0
Average number of days from planting until first fruit formed on plant	12	99.2	22.8	50.0	133.0

Questions 2-11: **Canister 3, Layer B, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	61	21.4	12.5	5.0	86.0
Germination rate: percent of seeds germinated 14 days after planting	58	76.8	17.8	20.0	100.0
Average number of days required for germination within 14 days after planting	46	7.6	2.6	3.0	14.0
Number of plants measured	36	11.6	8.0	2.0	33.0
Average height (cm) at 56 days	39	25.1	10.2	8.0	38.0
Average width (cm) at 56 days	34	14.5	2.9	7.0	16.0
Flowering rate: percent of plants producing flowers	9	63.2	32.8	19.0	100.0
Average number of days to first flower within 56 days	3	48.3	12.4	34.0	56.0
Percent of plants producing fruit	17	90.4	24.8	13.0	100.0
Average number of days from planting until first fruit formed on plant	12	99.3	23.6	46.0	119.0

"Our Young Astronauts constructed a model of LDEF and will display and outline the roles of other nations. Isn't that the essence of all successful human endeavors, among the most noble of them all our space program?"

—Edison, NJ (elementary)

Questions 2-11: **Canister 3, Layer C, Space-exposed Summary, College**

	Number reporting	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Number of seeds planted	61	25.3	19.2	5.0	146.0
Germination rate: percent of seeds germinated 14 days after planting	57	75.1	18.1	9.0	100.0
Average number of days required for germination within 14 days after planting	45	7.4	2.5	3.0	12.0
Number of plants measured	35	10.8	6.9	2.0	23.0
Average height (cm) at 56 days	38	26.0	9.6	8.0	38.0
Average width (cm) at 56 days	32	14.4	2.9	7.0	16.0
Flowering rate: percent of plants producing flowers	11	52.3	38.0	5.0	100.0
Average number of days to first flower within 56 days	3	45.7	11.1	34.0	56.0
Percent of plants producing fruit	17	90.6	25.2	10.0	100.0
Average number of days from planting until first fruit formed on plant	12	98.0	22.6	46.0	118.0

Questions 2-11: **Canister 3, Layer D, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	61	22.4	10.2	4.0	50.0
Germination rate: percent of seeds germinated 14 days after planting	58	76.6	18.3	23.0	100.0
Average number of days required for germination within 14 days after planting	46	7.5	2.6	3.0	14.0
Number of plants measured	34	10.9	6.9	2.0	23.0
Average height (cm) at 56 days	38	26.4	9.7	8.0	38.0
Average width (cm) at 56 days	32	14.3	3.0	7.0	16.0
Flowering rate: percent of plants producing flowers	10	57.2	38.7	4.0	100.0
Average number of days to first flower within 56 days	3	44.3	12.0	32.0	56.0
Percent of plants producing fruit	17	91.3	25.0	13.0	100.0
Average number of days from planting until first fruit formed on plant	12	95.0	20.7	41.0	111.0

"The students were excited and proud to be doing real research. They learned fine experimental skills and much about plant growth."

—Shafer Heights, OH.
(elementary)

Quesitons 2-11: **Earth-based Summary, Canister 3 Experimenters, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	61	39.5	40.3	5.0	316.0
Germination rate: percent of seeds germinated 14 days after planting	59	70.1	19.0	11.0	100.0
Average number of days required for germination within 14 days after planting	46	7.2	2.1	3.0	12.0
Number of plants measured	35	15.1	10.8	2.0	58.0
Average height (cm) at 56 days	38	26.2	9.5	13.0	38.0
Average width (cm) at 56 days	34	14.4	2.9	7.0	16.0
Flowering rate: percent of plants producing flowers	9	67.3	34.5	6.0	100.0
Average number of days to first flower within 56 days	3	44.7	11.0	34.0	56.0
Percent of plants producing fruit	17	92.4	22.9	10.0	100.0
Average number of days from planting until first fruit formed on plant	13	98.8	21.9	42.0	118.0

Questions 2-11: **Canister 4, Layer A, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	36	21.6	10.8	9.0	56.0
Germination rate: percent of seeds germinated 14 days after planting	34	67.9	26.3	5.0	100.0
Average number of days required for germination within 14 days after planting	32	8.4	2.6	3.0	14.0
Number of plants measured	16	10.7	5.4	4.0	22.0
Average height (cm) at 56 days	18	25.8	11.7	8.0	38.0
Average width (cm) at 56 days	15	14.2	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	6	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	1	44.0	—	44.0	44.0
Percent of plants producing fruit	7	85.3	33.6	10.0	100.0
Average number of days from planting until first fruit formed on plant	6	87.7	26.0	54.0	120.0

"We learned a lot from this experiment and enjoyed being a part of the NASA SEEDS project. The students felt important participating in what we felt would help make future decisions in space."

—Kansas City, MO. (elementary)

Questions 2-11: **Canister 4, Layer B, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	35	22.1	6.8	10.0	35.0
Germination rate: percent of seeds germinated 14 days after planting	36	67.2	26.4	7.0	100.0
Average number of days required for germination within 14 days after planting	33	8.5	2.7	2.0	13.0
Number of plants measured	16	12.3	4.7	5.0	21.0
Average height (cm) at 56 days	17	26.2	10.3	8.0	38.0
Average width (cm) at 56 days	15	14.4	3.7	4.0	16.0
Flowering rate: percent of plants producing flowers	6	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	1	46.0	—	46.0	46.0
Percent of plants producing fruit	7	85.3	36.4	3.0	100.0
Average number of days from planting until first fruit formed on plant	6	80.2	22.9	53.0	116.0

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Questions 2-11: **Canister 4, Layer C, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	34	21.5	8.1	2.0	33.0
Germination rate: percent of seeds germinated 14 days after planting	33	70.4	23.5	5.0	96.0
Average number of days required for germination within 14 days after planting	31	8.9	2.6	4.0	14.0
Number of plants measured	17	11.1	6.5	2.0	23.0
Average height (cm) at 56 days	17	26.8	9.6	13.0	38.0
Average width (cm) at 56 days	16	14.1	3.8	4.0	16.0
Flowering rate: percent of plants producing flowers	6	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	1	51.0	—	51.0	51.0
Percent of plants producing fruit	6	99.3	1.6	96.0	100.0
Average number of days from planting until first fruit formed on plant	5	82.0	25.8	56.0	120.0

"The project was useful for learning long division, averaging, and the use of hand calculators. Wednesdays were data sound off days and on one of these days a student remarked, 'Ha, ha, we didn't even have math today.' As I looked at the blackboard filled with numbers, then the student data sheets columned with numbers, well... all I could say to the student was, 'You know, you're right, no math today.'"

—Galeton, CO, (elementary)

Questions 2-11: **Canister 4, Layer D, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	35	22.8	7.8	10.0	41.0
Germination rate: percent of seeds germinated 14 days after planting	34	68.9	23.1	5.0	96.0
Average number of days required for germination within 14 days after planting	32	8.4	2.7	2.0	14.0
Number of plants measured	17	10.0	6.0	2.0	21.0
Average height (cm) at 56 days	18	25.2	11.1	8.0	38.0
Average width (cm) at 56 days	16	14.3	3.5	4.0	16.0
Flowering rate: percent of plants producing flowers	6	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	0	—	—	—	—
Percent of plants producing fruit	6	96.7	5.2	90.0	100.0
Average number of days from planting until first fruit formed on plant	5	84.2	32.1	49.0	122.0

Questions 2-11: **Earth-based Summary, Canister 4 Experimenters, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	35	30.5	15.6	10.0	70.0
Germination rate: percent of seeds germinated 14 days after planting	36	64.3	23.8	10.0	93.0
Average number of days required for germination within 14 days after planting	31	8.5	1.9	4.0	12.0
Number of plants measured	19	15.8	9.4	1.0	34.0
Average height (cm) at 56 days	20	25.3	10.7	8.0	38.0
Average width (cm) at 56 days	16	14.1	4.1	4.0	16.0
Flowering rate: percent of plants producing flowers	6	100.0	0	100.0	100.0
Average number of days to first flower within 56 days	1	49.0	—	49.0	49.0
Percent of plants producing fruit	7	86.1	29.9	19.0	100.0
Average number of days from planting until first fruit formed on plant	6	81.0	21.0	55.0	112.0

> ***"My classes were very excited to be a part of a national study and displayed very accurate data collection throughout."***
>
> —Rogers, TX (secondary)

Questions 2-11: **Canister 5, Layer A, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	35	24.4	16.4	3.0	88.0
Germination rate: percent of seeds germinated 14 days after planting	35	65.3	23.2	6.0	100.0
Average number of days required for germination within 14 days after planting	26	8.5	3.1	3.0	13.0
Number of plants measured	19	11.6	8.2	2.0	29.0
Average height (cm) at 56 days	19	21.7	9.9	8.0	38.0
Average width (cm) at 56 days	18	14.2	3.6	4.0	16.0
Flowering rate: percent of plants producing flowers	5	89.0	9.9	75.0	100.0
Average number of days to first flower within 56 days	2	43.5	2.1	42.0	45.0
Percent of plants producing fruit	7	95.3	9.7	74.0	100.0
Average number of days from planting until first fruit formed on plant	6	86.5	20.2	52.0	105.0

Questions 2-11: **Canister 5, Layer B, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	34	22.5	14.4	2.0	88.0
Germination rate: percent of seeds germinated 14 days after planting	35	59.3	25.8	7.0	100.0
Average number of days required for germination within 14 days after planting	26	8.3	3.0	3.0	13.0
Number of plants measured	18	11.9	8.8	1.0	29.0
Average height (cm) at 56 days	17	22.4	11.2	8.0	38.0
Average width (cm) at 56 days	15	13.4	3.9	4.0	16.0
Flowering rate: percent of plants producing flowers	6	80.5	27.9	33.0	100.0
Average number of days to first flower within 56 days	3	40.3	5.7	34.0	45.0
Percent of plants producing fruit	8	85.6	24.6	33.0	100.0
Average number of days from planting until first fruit formed on plant	6	76.7	27.3	37.0	105.0

"Terrific learning experience— Thank you for the SEEDS Project. It was a great science motivator."

—Buena Park, CA (elementary)

Questions 2-11: **Canister 5, Layer C, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	33	20.6	9.0	2.0	35.0
Germination rate: percent of seeds germinated 14 days after planting	31	67.5	25.9	11.0	100.0
Average number of days required for germination within 14 days after planting	25	8.1	2.5	5.0	13.0
Number of plants measured	16	13.2	8.7	1.0	29.0
Average height (cm) at 56 days	15	23.7	10.5	8.0	38.0
Average width (cm) at 56 days	14	14.7	2.6	7.0	16.0
Flowering rate: percent of plants producing flowers	5	64.0	40.9	20.0	100.0
Average number of days to first flower within 56 days	4	42.0	4.2	36.0	45.0
Percent of plants producing fruit	8	87.5	28.2	20.0	100.0
Average number of days from planting until first fruit formed on plant	8	81.6	24.4	40.0	105.0

Questions 2-11: **Canister 5, Layer D, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	33	20.8	8.9	3.0	33.0
Germination rate: percent of seeds germinated 14 days after planting	31	67.6	23.6	10.0	100.0
Average number of days required for germination within 14 days after planting	25	7.9	2.8	2.0	13.0
Number of plants measured	16	11.7	9.4	1.0	29.0
Average height (cm) at 56 days	15	22.0	9.9	8.0	38.0
Average width (cm) at 56 days	14	13.4	4.1	4.0	16.0
Flowering rate: percent of plants producing flowers	5	71.4	35.4	25.0	100.0
Average number of days to first flower within 56 days	3	43.0	1.7	42.0	45.0
Percent of plants producing fruit	6	97.8	5.3	87.0	100.0
Average number of days from planting until first fruit formed on plant	6	94.0	33.5	52.0	150.0

> ***"I benefited tremendously from this opportunity to use my science teaching skills and from the reward of student enthusiasm in the learning of this subject."***
>
> —Wilmerding, PA
> (middle school)

Questions 2-11: **Earth-based Summary, Canister 5 Experimenters, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	36	33.5	23.5	4.0	121.0
Germination rate: percent of seeds germinated 14 days after planting	35	65.9	27.6	4.0	100.0
Average number of days required for germination within 14 days after planting	26	8.6	2.9	4.0	14.0
Number of plants measured	17	16.9	24.3	2.0	96.0
Average height (cm) at 56 days	18	21.9	9.6	8.0	38.0
Average width (cm) at 56 days	16	13.6	3.8	4.0	16.0
Flowering rate: percent of plants producing flowers	6	65.0	38.4	4.0	100.0
Average number of days to first flower within 56 days	4	42.8	2.9	39.0	45.0
Percent of plants producing fruit	5	97.4	5.8	87.0	100.0
Average number of days from planting until first fruit formed on plant	5	87.4	19.6	59.0	105.0

Questions 2-11: **Canister 7, Layer A, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	74	22.6	10.3	6.0	91.0
Germination rate: percent of seeds germinated 14 days after planting	73	74.6	19.1	11.0	100.0
Average number of days required for germination within 14 days after planting	61	7.7	2.4	3.0	14.0
Number of plants measured	31	13.4	12.9	1.0	75.0
Average height (cm) at 56 days	31	29.6	8.7	13.0	38.0
Average width (cm) at 56 days	29	14.4	3.3	4.0	16.0
Flowering rate: percent of plants producing flowers	15	68.7	33.1	11.0	100.0
Average number of days to first flower within 56 days	4	49.0	5.7	42.0	56.0
Percent of plants producing fruit	22	82.5	23.5	3.0	100.0
Average number of days from planting until first fruit formed on plant	19	88.1	28.5	45.0	150.0

"My fifth graders learned that NASA does much to benefit our nation. Thanks again for this opportunity."

—Garland, TX (elementary)

Questions 2-11: **Canister 7, Layer B, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	71	23.9	10.1	6.0	80.0
Germination rate: percent of seeds germinated 14 days after planting	69	74.1	19.7	17.0	100.0
Average number of days required for germination within 14 days after planting	59	7.8	2.3	3.0	14.0
Number of plants measured	32	14.3	10.9	1.0	58.0
Average height (cm) at 56 days	31	28.9	9.3	13.0	38.0
Average width (cm) at 56 days	29	14.6	3.6	4.0	16.0
Flowering rate: percent of plants producing flowers	12	70.4	35.8	9.0	100.0
Average number of days to first flower within 56 days	3	47.0	4.4	42.0	50.0
Percent of plants producing fruit	21	73.9	27.3	6.0	100.0
Average number of days from planting until first fruit formed on plant	16	83.4	20.5	56.0	121.0

Questions 2-11: **Canister 7, Layer C, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	73	23.8	10.9	4.0	91.0
Germination rate: percent of seeds germinated 14 days after planting	71	74.1	19.6	21.0	100.0
Average number of days required for germination within 14 days after planting	61	7.7	2.4	3.0	14.0
Number of plants measured	33	14.7	12.9	1.0	75.0
Average height (cm) at 56 days	32	27.8	10.0	8.0	38.0
Average width (cm) at 56 days	28	14.7	2.9	4.0	16.0
Flowering rate: percent of plants producing flowers	12	83.2	28.0	14.0	100.0
Average number of days to first flower within 56 days	4	48.8	5.7	42.0	56.0
Percent of plants producing fruit	24	74.5	27.6	9.0	100.0
Average number of days from planting until first fruit formed on plant	19	81.9	23.9	45.0	127.0

"Thank you for the opportunity to involve my students in the wonderful project. They learned to integrate subjects, i.e., English, history, math, and science, had a good time doing so, and felt very important."

—Woburn, MA (middle school)

Questions 2-11: **Canister 7, Layer D, Space-exposed Summary, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	71	24.2	11.1	6.0	92.0
Germination rate: percent of seeds germinated 14 days after planting	70	73.4	19.9	2.0	100.0
Average number of days required for germination within 14 days after planting	58	7.6	2.4	4.0	14.0
Number of plants measured	32	13.9	13.3	1.0	75.0
Average height (cm) at 56 days	32	27.7	9.7	13.0	38.0
Average width (cm) at 56 days	30	14.1	3.7	4.0	16.0
Flowering rate: percent of plants producing flowers	13	73.4	36.2	1.0	100.0
Average number of days to first flower within 56 days	3	47.0	4.4	42.0	50.0
Percent of plants producing fruit	21	80.3	26.1	15.0	100.0
Average number of days from planting until first fruit formed on plant	18	80.8	23.1	45.0	130.0

Questions 2-11: **Earth-based Summary, Canister 7 Experimenters, College**

	Number reporting	Mean	Std. Dev.	Min.	Max.
Number of seeds planted	75	36.7	22.6	4.0	121.0
Germination rate: percent of seeds germinated 14 days after planting	71	75.6	18.2	16.0	100.0
Average number of days required for germination within 14 days after planting	60	8.1	2.6	3.0	14.0
Number of plants measured	32	22.6	20.6	1.0	96.0
Average height (cm) at 56 days	32	27.5	10.0	8.0	38.0
Average width (cm) at 56 days	30	14.6	3.2	4.0	16.0
Flowering rate: percent of plants producing flowers	14	66.9	36.0	15.0	100.0
Average number of days to first flower within 56 days	5	50.2	5.9	42.0	56.0
Percent of plants producing fruit	22	80.9	26.2	13.0	100.0
Average number of days from planting until first fruit formed on plant	18	83.3	25.2	40.0	137.0

"The students were very excited about the experiments. They were disappointed because the plants did not bear fruit for them, but they felt that they learned by being part of the experiment and keeping records of their plants' growth."

— Charleston, SC (elementary)

Question 15: **Growth Conditions of Plants After Four True Leaves Developed, College**

Data about the growing environment of the tomato plants after four true leaves had developed are displayed in this table. For more information on the effects of the growing conditions on the plants consult the six correlation tables beginning on page 83. The data presented in those tables are from grades 5-9, giving clues as to the effects of differing growth environments on the space-exposed plants and their Earth-based controls. College data were insufficient to correlate by growing conditions or by type of germination media used.

Growth Conditions	Number reporting	Growth Conditions	Number reporting
Plants grown indoors	166	Plants grown outdoors	95
Grown in window facing South	49	Grown in window facing North	12
Grown in window facing West	26	Grown in window facing East	24
Grown in window facing Northeast	4	Grown in window facing Northwest	2
Grown in window facing Southeast	9	Grown in window facing Southwest	8
Grown under fluorescent light	53	Grown under incandescent light	16
Grown under other types of light	5	Grown under Gro-lites	28
Grown inside- container 11 L (3 gal) or less	152	Grown outside- container 11 L (3 gal) or less	34
Grown inside- container 15 L (4 gal)	8	Grown outside- container 15 L (4 gal)	4
Grown inside- container 19 L (5 gal)	6	Grown outside- container 19 L (5 gal)	6
Grown inside- container 23 L (6 gal)	2	Grown outside- container 23 L (6 gal)	3
Grown inside- container 27 L (7 gal) or more	8	Grown outside- container 27 L (7 gal) or more	7
Grown in garden plot	77	Grown in full sun	75
Grown in partial shade	41	Grown in full shade	4
Grown in Greenhouse	108		

Questions 20-23: **Biochemical Tests Conducted, College**

Data presented in this table document the types of biochemical tests performed by reporting researchers. Results from these tests, as well as microbial tests (questions 16-18) are discussed in the narrative portion of *SEEDS: A Celebration of Science*. Again, very few anecdotal notes were received. Insufficient information concerning chromosome tests (question 19) was received for reporting purposes.

	layer A		layer B		layer C		layer D		Earth-based	
	Y	**N**	**Y**	**N**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Was a chromatographic test conducted on the plants?	8	5	11	2	8	4	10	3	8	4
Was a chromatographic test conducted on the seeds?	1	8	0	7	1	7	0	7	1	6
Was a spectrophotometric test conducted on the plants?	2	5	2	5	2	5	2	5	2	5
Was a spectrophotometric test conducted on the seeds?	1	7	1	6	1	6	1	6	1	6
Was an auxin identification analysis conducted on the plants?	1	6	1	5	1	5	1	5	1	5
Was an auxin identification analysis conducted on the seeds?	0	8	0	7	0	7	0	7	0	7
Was an electrop[illegible] analysis conducted on the plants?	5	6	5	5	5	5	5	5	5	5
Was an electrophoresis analysis conducted on the seeds?	1	8	1	7	1	7	1	7	1	7

> ***"We used it for oral language, timelines, math, and science. It is a great way to hook kids to NASA goals and objectives and be forward looking. . .kids look for a hope for thier future."***
>
> — Charleston, SC, (elementary)

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Questions 24-26: **School Classrooms Reporting SEEDS Data, College**

This table presents information about the colleges that reported data. The information is arranged by the institution's total enrollment.

	School Enrollment 15,000+	**School Enrollment 5,000-14,999**	**School Enrollment 1,500-4,999**	**School Enrollment 500-1,499**	**School Enrollment Below 500**
Number of public 2 years schools reporting	8	13	26	15	4
Public 2 years schools as percent of total public and private	3.4	5.5	11.1	6.4	1.7
Number of private 2 years schools reporting	0	0	1	5	3
Private 2 years schools as percent of total public and private	0	0	.4	2.1	1.2
Number of public 4 or 4+ years schools reporting	30	27	22	11	4
Public 4 or 4+ years schools as percent of total public and private	12.8	11.5	9.4	4.7	1.7
Number of private 4 or 4+ years schools reporting	8	11	23	19	5
Private 4 or 4+ years schools as percent of total public and private	3.4	4.7	9.8	8.1	2.1
Participated in agriculture class	5	6	7	3	3
Participated in mathematics class	0	1	1	0	0
Participated in science class	29	36	59	44	12
Participated in other type of class	10	6	12	6	5

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Questions 24 and 26: **School Classrooms Reporting SEEDS Data, College**

	2 Years Public	2 Years Private	4 Years Public	4 Years Private
Participated in agriculture class	10	1	11	2
Participated in mathematics class	2	0	0	0
Participated in science class	44	7	68	56
Participated in other type of class	12	1	15	8

Questions 27, 29, 30: **Experimental Design, Continuation, and Termination, College**

	Number Reported	Percent of Total
Performed NASA-suggested experiments	215	88.5
Performed student-designed experiments	28	11.5
Plans to continue experiments with subsequent generations of seeds	116	45.1
Does not plan to continue experiments with subsequent generations of seeds	141	54.9
Terminated the experiment when the required observations for the report were completed	116	54.0
Terminated the experiment when the plants died or the experiment was interrupted	40	18.6
Terminated the experiment for other reasons	59	27.4

> ***"This has been an excellent 'hands-on' science experiment for participants. Much interest has been generated by participating and nonparticipating students!"***
>
> —McFarland, WI (elementary)

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The upper table displays the total number of students who participated in the classes represented by the 8,000+ data forms that were returned to NASA. Foreign countries receiving SEEDS kits are listed in the lower table.

Number of Students Participating in SEEDS as Indicated by Reporting Schools

Grade Level	Number of Students
Elementary, Grades 5-9	232,968
High School, Grades 10-12	45,271
College	4,627

Foreign Countries Participating in SEEDS

- Argentina
- Australia
- Austria
- Bahrain
- Barbados
- Bermuda
- Brazil
- Canada
- Columbia
- Egypt
- England
- France
- Germany
- Hong Kong
- Iceland
- Japan
- Korea
- Kuwait
- Morocco
- Norway
- Oman
- Peru
- Phillipines
- Republic of South Africa
- Saipan
- Saudi Arabia
- Singapore
- Sweden
- Thailand
- West Indies

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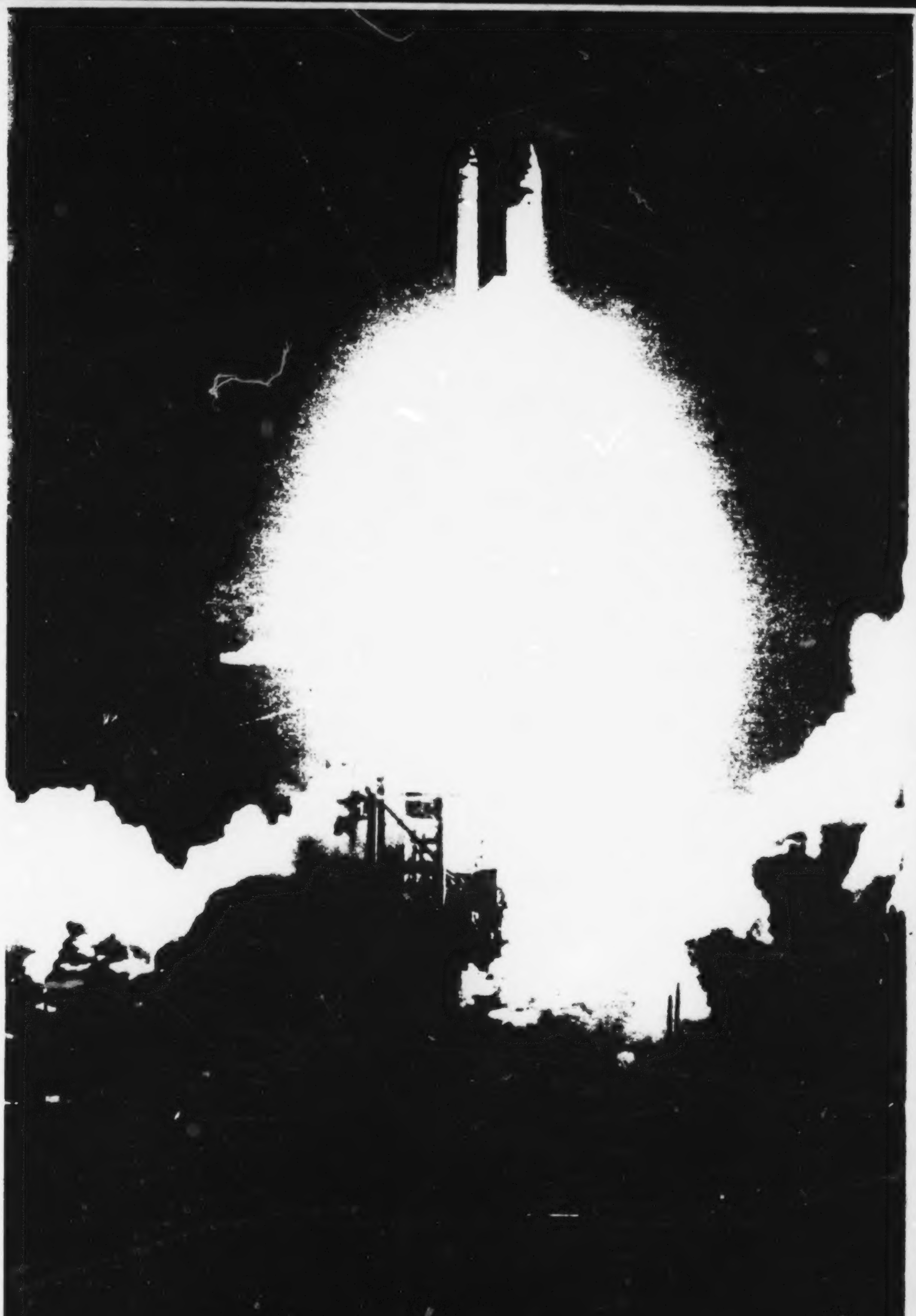
Launch of retrieval mission

STS-32



"I would like to thank you for making the young people of America feel like a part of your program."

—Sunbury, PA (elementary)

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